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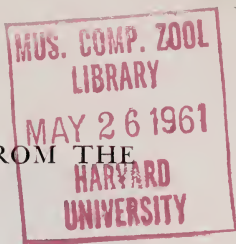
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ART. 1. NEW AND LITTLE KNOWN *PHYSA* FROM THE
PALEOCENE OF PATAGONIA

By JUAN J. PARODIZ
Curator of Invertebrates
Carnegie Museum



Physa wichmanni, sp. nov. (Fig. 1, 1-6.)

Shell medium-sized, subrimate, elongate-ovate. Widest diameter scarcely exceeding a half of the total length (ratio 1.95). $6\frac{1}{2}$ whorls. Last whorl occupying almost $\frac{3}{4}$ of the length (ratio 1.26). Suture not margined but well marked, with inclination of 23° . On the last whorl, the surface shows rather strong and very regular growth lines. It also presents a dark-banded zone as occurs in some living species. Aperture elongated, rounded at the base, with columellar margin straight, and a little expanded. The interior of the shell is filled with tuffaceous matrix.

Except for a small broken portion of the peristome, the holotype is very well preserved, with the tip of the protoconch complete and partly crystallized by infiltration of silica solution. The dimensions are given in Table 1.

Holotype. Bajo Santa Rosa, 50 miles south of Negro River at Chelforo, province of Rio Negro, Argentina, from beds of the Jahuel Formation (Danian); collector Dr. R. Wichmann 1915. Two other specimens are from the same stratum, of Nahuel Niyeu, a southern locality near Valcheta; one of these is smaller, with the columellar lip submargined, and surface with strong and regularly spaced, costulae-like, lines of growth; the other, larger, is flattened and distorted by pressure of the sediments, a condition common to many fresh-water shells found in the same formation.

From the same region and beds, another but very different species was previously described:

Physa doeringi Doello Jurado 1927. (Fig. 1, 7-8.)

Boletin Academia Nacional de Ciencias en Córdoba, v. 30, p. 411, plate 11, fig. 76. (The figure referred to in the description, and included in the reprint of the paper, actually corresponds to a preceding paper in the same volume, p. 385, by R. Wichmann.)

This is a gigantic and very inflated form, with only five whorls, more than twice as large as *wichmanni*, and with shorter spire in relation to its diameter. The type locality is Trapalcó, in the Bajo de los Menucos, a southwestern continuation of the depression of Santa Rosa, and another specimen was collected also by Dr. Wichmann in the same type locality of our *Physa wichmanni*. Both species were also found at Nahuel Niyeu.

Doello Jurado mentioned young specimens of *doeringi*, but with them were mixed those of *wichmanni* above described. Another specimen from Santa Rosa is even larger than the type of *doeringi*.

The general shape of *P. doeringi*, recalls the African *Physopsis* of the *Planorbidae* which according to Connolly also reaches very large sizes. The differences are mainly anatomical, and for paleogeographical reasons which made such relationship very unlikely, there is less risk in maintaining the Patagonian species from the paleocene in *Physa*, s.s.

As both species occur in the same localities, Doello Jurado was inclined to assume that the specimens here described as *wichmanni* were *doeringi* not fully developed. But the differences are obvious as shown in the illustrations and the measurements in Table 1.

TABLE 1. *P. WICHMANNI* AND *P. DOERINGI*
Dimensions in millimeters

	<i>wichmanni</i>		Trapalcó	<i>doeringi</i>	
	Santa Rosa	Nahuel Niyeu		Santa Rosa	Nahuel Niyeu
Length	15.6	19*	38	35	13.8
Major diameter	8	10**	25.5	27	8.5
Minor diameter	7.8	8.5**	19	23	7.5
Last whorl	12.3	14	30***	***	***
No. of whorls	6½	7	5	4½	5
Sutural angle	23°	26°	10°	15°	
Ratio $\frac{\text{Length}}{\text{Major diameter}}$	1.95	1.9	1.49	1.29	1.72

* Base partially fractured. ** Specimens distorted by pressure. *** Not complete.

Stratigraphy. The fluvial-lacustrine Jahuel Formation was included by earlier authors in the Upper Cretaceous (Maastrichtian) and referred to in the geological literature under various names: "Strata with Dinosaurs," "Lacustrine Senonian" or "Pehuenche Formation." The name Jahuel Formation (Windhausen 1918) is the first available and acceptable term according to the present standards of stratigraphical nomenclature. Recent studies allowed correction of its age, which is Paleocene (mostly Danian and in part Montian. Chronologically correspondent to the Fort Union Formation in North America and Puca Formation of Perú and Bolivia, bearing paleontological affinities with the last). Synchronous with the marine "Rocanean" and "Salamancan" (San Jorge Formation). In the same localities and with our *Physa*, were found *Diplodon bondenbenderi* Doello-Jurado, *Diplodon pehuenchensis* Doello-Jurado, *Valvata windhauseni* Parodiz, several species of *Viviparus* and "*Melania*" *ameghiniana* Doello-Jurado (probably a Pleurocerid) and fish remains (*Ceratodus*). The fresh-water deposits gradually pass to brackish-water environments, sometimes mixed with the marine, and others underlying them, but always above the Senonian in unconformity. George Gaylord Simpson's Rio Chico Formation, bearing the earliest Patagonian mammal

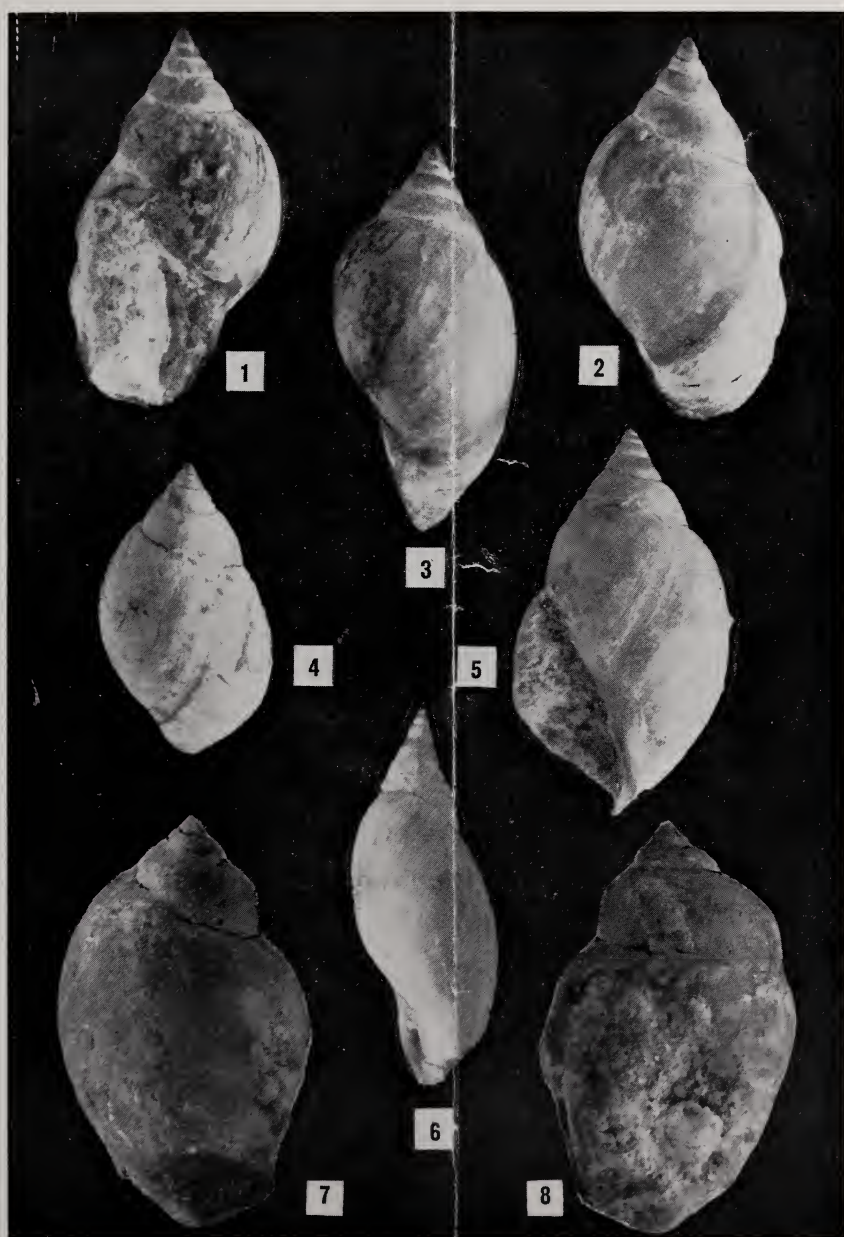


Fig. 1. *Physa wichmanni* and *Physa doeringi*

1—3. *Physa wichmanni*, sp. nov., Santa Rosa, holotype, $\times 2$. 4. *Physa wichmanni*, small specimen from Nahuel Niyeu, enlarged $1/3$. 5—6. *Physa wichmanni* (specimen deformed by diastrophic pressure) Nahuel Niyeu, $\times 2$. 7—8. *Physa doeringi* Doello Jurado, type, Santa Rosa, enlarged $1/4$.

fauna, is a lateral terrestrial equivalent (of the upper section) of Jahuel Formation.

At the end of the Paleocene the *Physa* disappeared from this region, and are present again only in the Pliocene-Pleistocene. It is presumable that the living South American species derived from a modern northern migration, rather than being related to the old tertiary species.



ART. 2. SYNOPSIS OF THE GENERA OF HYLID FROGS

BY COLEMAN J. GOIN

University of Florida and Research Associate, Carnegie Museum

When I began the study of South American tree frogs of the family Hylidae I found it necessary to draft out a list of the genera that I consider valid, together with a list of the synonyms of each genus. In the hope that this list may prove useful to others concerned with the group, I have prepared it for publication so that it may be generally available.

Now surely very few people indeed will see eye to eye with me on just which genera should, and which should not, be recognized. This is partly due to subjective differences of opinion and partly due to different experiences with the forms in question. I have in the main tried to avoid either extreme but am perhaps more inclined to recognize genera for the sake of emphasizing differences rather than to synonymize them and emphasize similarities. For example, *Osteocephalus*, with the paired vocal pouches in the male and with the invariably exostosed skull, seems to me to represent a natural assemblage; I feel that it is much better for us to recognize it nomenclatorially than it is for us to mask our knowledge by simply including it in the all too large genus *Hyla*. Nor have I failed to recognize genera simply because they are difficult of definition. I believe that in many cases this difficulty may be as much due to lack of knowledge by the herpetologists as it is to the nature of the frogs in question.

Many of the genera included herein are extremely difficult to define adequately so that it is not to be expected that the keys and diagnoses will prove infallible. While many of the genera are remarkably distinct, others, such as *Pseudacris* and *Hyloscirtus*, are quite *Hyla*-like. Furthermore, some, such as *Nyctimystes* and *Agalychnis*, while surely of independent origin, are distressingly similar. As our knowledge of these difficult genera grows, our concepts of them will become clearer and more precise. Until then, keys and diagnoses of these forms must be considered tentative.

As far as the synonymies are concerned, I have made them as complete as my knowledge permitted. In such a mass of literature it is most probable that I have too many names escape my attention. I can only hope there have not been let some.

While the diagnosis and keys are designed to help identify the genera, they should in no sense be construed as attempts to point out relationships. The question of relationships among the various hylid genera is one that will offer substantial problems to students of frogs for some time to come. Thus in the present list the various "helmeted" hylids have been retained in the separate genera originally erected for them. The final decision as to which of these genera should be recognized because they represent independent derivatives of the genus *Hyla*, and which should be lumped together because they are representatives of a single homogeneous stock, will have to await more intensive and extensive anatomical studies on these frogs than have yet been made.

This list perhaps really had its origin when my friend Werner C. A. Bokermann first queried me concerning some genera he was working on. In

attempting to answer his questions I raised many new ones that I could not let go unanswered and so, like Mr. Finney's turnip, the project grew. It was my first intention to include only South American genera, but as several South American genera range into Central America, and vice versa, it seemed only logical to include all the Middle American forms. Since only three, *Acris*, *Pseudacris*, and *Nyctimystes*, occur entirely outside of South and middle America, I decided to include all genera for the sake of completeness.

In addition to Mr. Bokermann, several other friends have been kind in both encouraging me to publish my list and in letting me examine material in their care. I would like to mention in particular Charles M. Bogert, American Museum of Natural History; Doris M. Cochran, United States National Museum, who first introduced me to South American frogs and with whom I am associated in a study of the frogs of Colombia; Alice G. C. Grandison, British Museum (Natural History); Prof. Jean Guibé, Museum National d'Histoire Naturelle; Robert F. Inger, Chicago Natural History Museum; George S. Myers, Stanford University; Hermano Nicéforo Maria, Institute de La Salle; William Riemer, University of Florida; E. H. Taylor, formerly of the University of Kansas; Charles F. Walker, Museum of Zoology; and Ernest E. Williams, Museum of Comparative Zoology. The manuscript list of the Hylidae of the world by John Condit was very useful to me and I want to thank Mr. Condit for the privilege of studying it. Travel to various museums was made possible by a Grant (G-5628) from the National Science Foundation and travel to London and Paris was also aided by a grant from the American Academy of Arts and Sciences. Work on the project during the summer of 1959 was made possible by a Grant (G-8625) from the National Science Foundation.

Hylidae

The Hylidae is here considered to include frogs with procoelous vertebrae; a double condyle on the coccyx; arciferal girdle; short intercalary cartilages between the ultimate and penultimate phalanges; claw-shaped terminal phalanges.

From the other four families of frogs with intercalary cartilages it may be distinguished as follows: from the Centrolenidae in having the terminal phalanges claw-shaped rather than T-shaped; from the Pseudidae in having the intercalary cartilages disk-like rather than elongate and rod-like; and from both the Rhacophoridae and Phrynomeridae in being procoelous and arciferal rather than diplasiocoelous and firmisternal.

Acris Duméril and Bibron

1841 *Acris* Duméril and Bibron, *Erpétologie générale*, v. 8, p. 506, type *Rana gryllus* LeConte.

Diagnosis.—Aquatic hylids with reduced digital disks; feet extensively webbed; sacral diapophyses but little if at all expanded.

Notes.—A North American genus with five nominal forms east of the Rocky Mountains.

Agalychnis Cope

1864 *Agalychnis* Cope, *Proceedings of the Academy of Natural Science of Philadelphia*, v. 16, p. 181, type *Hyla callidryas* Cope.

Diagnosis.—Vertical pupil; palpebral membrane reticulate in all except *A. calcarifer*; tongue extensively free behind; webbing well developed on feet;

first toe shorter than second; vocal pouch of male median and subgular; eyes red in life in many of the species.

Notes. — Some ten species distributed from Mexico to Ecuador.

Amphignathodon Boulenger

1882 *Amphignathodon* Boulenger, Catalogue Batrachia Salientia, p. 450, type *Amphignathodon güntheri* Boulenger.

Diagnosis. — Teeth present on mandible but not on palatine or parasphenoid; pouch present on back of female.

Notes. — A single living species, *A. güntheri*, known from the Andes of Ecuador. A fossil species from the Tertiary of Europe has been, probably erroneously, referred to this genus.

Amphodus Peters

1872 *Amphodus* Peters, Monatsberichte Akademie Wissenschaft, Berlin, p. 768, type *Amphodus wuchereri* Peters.

1923 *Lophiophyla* Mirando-Ribeiro, Boletim Museu Nacional, Rio de Janeiro, no. 1, p. 5, type *Lophiophyla piperata* Mirando-Ribeiro.

Diagnosis. — Skin of head not co-ossified with skull; roof of skull not exostosed; teeth (odontoids) on mandible, palatines and parasphenoid; a single subgular vocal pouch.

Notes. — There are three nominal species recorded in this little-known genus, *auratus*, *piperatus*, and *wuchereri*.

Anotheca Smith

1939 *Anotheca* Smith, Biological Society of Washington, Proceedings, v. 52, p. 190, type *Gastrotheca coronata* Stejneger.

Diagnosis. — Derm of head co-ossified with skull; no teeth on mandible, palatines, or parasphenoid; no pouch on back of female; posterior margin of helmet studded with erect, conical, bony spines; snout not produced into an anterior projecting proboscis.

Notes. — A single species, *A. coronata*, ranges from Panama to Veracruz, Mexico.

Aparasphenodon Mirando-Ribeiro

1920 *Aparasphenodon* Mirando-Ribeiro, Revista Paulista Museu, v. 12, p. 87, type *Aparasphenodon brunoï* Mirando-Ribeiro.

Diagnosis. — Derm of head co-ossified with skull to form a casque; canthal ridges fusing anteriorly and projecting beyond upper lip to form a point-like proboscis; external nares opening nearly laterally; palatine but not parasphenoid teeth present; choanae elongated; paired lateral vocal sacs in the male.

Notes. — The three nominal forms, *apicalis*, *adspersa*, and *brunoï*, all probably belong to a single species.

Aplastodiscus A. Lutz

1950 *Aplastodiscus* A. Lutz, in Lutz, B, Memórias Instituto Oswaldo Cruz, v. 48, p. 612, type *Aplastodiscus perviridis* A. Lutz.

Diagnosis. — Digital disks thin and narrow, generally no wider than digits; digits themselves narrow and frail, with poorly ossified phalanges. Otherwise *Hyla*-like.

Notes. — Very little is known about this small frog, no specimens of which are yet available in North America. Apparently it lives in open glades and

marshes in the mountainous regions of southern Brazil. *A. perviridis* is the only known species.

Cerathyla Espada

1871 *Cerathyla* Espada, Jornal de Sciencias, mathematicas, physicas et naturaes Lisboa, v. 3, p. 63, type *Cerathyla bubalis* Espada.

Diagnosis.—A well developed helmet but derm of head not co-ossified with skull; teeth or odontoids present on mandible and palatines; expanded digital pads present; eye placed midway between tip of snout and angle of jaw.

Notes.—Some half-dozen nominal species occur in the western portion of northern South America from Peru, and Amazonas, Brazil, to Panama.

Corythomantis Boulenger

1896 *Corythomantis* Boulenger, Annals and magazine of natural history, v. 17, p. 405, type *Corythomantis greeningi* Boulenger.

Diagnosis.—Derm of head co-ossified with skull to form a casque; canthal ridges not fused anteriorly and projecting not at all or little beyond the rounded tip of snout; external nares opening upward; no palatine teeth; choanae small and nearly rounded; paired lateral vocal sacs in the male.

Notes.—Three nominal species known—*greeningi*, *venezolana*, and *schubarti*.

Cryptobatrachus Ruthven

1916 *Cryptobatrachus* Ruthven, Occasional papers Museum of Zoology, no. 33, p. 1, type *Cryptobatrachus boulengeri* Ruthven.

Diagnosis.—Vomerine teeth in two nearly straight, transverse series which nearly touch on the midline and which lie behind the rounded choanae; sacral diapophyses nearly rounded; female carries the eggs on her back; eggs hatch directly into frogs; a single subgular vocal pouch in the male.

Notes.—This genus includes the nominal forms *evansi*, *boulengeri*, *incertus*, and *fuhrmanni*. *C. evansi* of British Guiana seems to be distinct but the status of those from the northern Andes is still in some doubt. Probably not more than two of them are valid and possibly only one valid species occurs there.

Dryomelictes Fitzinger

1838 *Sphoenorhynchus* Tschudi, Memoires Société neuchâtoise des Sciences naturelles, Neuchâtel, p. 71, type *Hyla lactea* Daudin [preoccupied by *Sphoenorhynchus* Lichtenstein, 1823, (Aves)].

1843 *Dryomelictes* Fitzinger, Systema reptilium, p. 31, type *Hyla lactea* Daudin.

1865 *Dryomelictes* Cope, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 17, p. 194, type *Hyla aurantiaca auctorum*.

1938 *Sphenohyla* Lutz and Lutz, Añais Academica Brasileira de Sciencias, v. 10, p. 178, type *Hyla lactea* Daudin (substitute for *Sphoenorhynchus*, preoccupied).

Diagnosis.—Moderate to small frogs, bright green or yellowish green in life; snout very pointed and projecting in lateral view; male with the external vocal pouch made up of longitudinal folds, bounded anteriorly and posteriorly by transverse folds; a posteriorly projecting process on the ischium; reduced number of maxillary teeth [33 on one side, the greatest number now known (*lactea*)]; prefrontals not in contact. Very aquatic.

Notes.—The following known species seem to belong to this genus: *lactea*,

dorisae, *planicola*, *orophila*, *habra*, and *seabrai*. My friend, Werner C. A. Bokermann, says that from his study of the forms in life he does not believe that *H. nana* should be assigned to this genus. The elimination of *nana* probably makes it a more natural, compact group.

Diaglena Cope

1887 *Diaglena* Cope, United States National Museum, Bulletin v. 32, p. 12, type *Triprion spatulata* Günther.

Diagnosis. — Teeth on the palatines and parasphenoid but not the mandible; cranial derm fused to skull, and skull forming a "helmet."

Notes. — Two species, *spatulata* and *reticulata*, occur in Mexico.

Flectonotus Miranda-Ribeiro

1926 *Flectonotus* Miranda-Ribeiro, Arquivos Museu Nacional, Rio de Janeiro, v. 27, p. 109, type *Flectonotus ulei* Miranda-Ribeiro.

Diagnosis. — Rather small frogs (circa 25 mm.); a pouch on the back of the female in the form of a longitudinal, slit-like trough; derm of head co-ossified with skull. The slit-like pouch and the small size distinguish this from *Gastrotheca* while the casque head separates it from *Nototheca*.

Notes. — The species, *F. ulei*, seems to be the only one that should be included here. This is one of the two genera herein recognized that I have not seen. The other is *Aplastodiscus*.

Fritzia Mello-Leitão

1920 *Fritzia* Miranda-Ribeiro, Revista Museu Paulista, v. 12, p. 321, type *Hyla goeldi* Boulenger [preoccupied by *Fritzia*, Cambridge, 1879 (Arachnida)].

1937 *Fritzia* Mello-Leitão, ser. 5a, Brasiliana, v. 77, Companhia Editoria Nacional, São Paulo, p. 330 (substitute name for *Fritzia* Miranda-Ribeira, preoccupied).

Diagnosis. — The only feature I know that will separate this from *Hyla* is the basin-like structure on the back of the female in which the eggs rest. Within this basin each individual egg has its own minor depression, reminiscent of the condition in *Cryptobatrachus*. I strongly suspect that careful anatomical studies will reveal the presence of structural features not associated with the life history to set this off from *Hyla*.

Notes. — A single species, *F. goeldi*, is known.

Gastrotheca Fitzinger

1843 *Gastrotheca* Fitzinger, Systema reptilium, fasc. 1, Amblyglossae, p. 30, type *Hyla marsupiata* Duméril and Bibron.

1854 *Notodelphys* Lichtenstein and Weinland, Berliner Akademische Wissenschaft, p. 373, type *Notodelphys ovifera* Lichtenstein and Weinland [preoccupied by *Notodelphys* Allman 1847 (Crustacea)].

1858 *Nototrema* Günther, Catalogue Batrachia Salientia, p. 115, type *Hyla marsupiata* Duméril and Bibron.

1858 *Opisthodelphis* Günther, Catalogue Batrachia Salientia, p. 117, type *Notodelphys ovifera* Lichtenstein and Weinland.

Diagnosis. — Medium to large-size hylids without teeth on the mandible, palatines or parasphenoid; with a well defined pouch on the back of the female, opening posteriorly either by a round, puckered aperture or by a

longitudinal slit but the pouch never a slit-like trough as in *Nototheca*; adult male with a rudimentary pouch on the back and a single, unpaired, vocal pouch; vomerine teeth in two short series; derm of the head may be co-ossified with the skull or it may be free in which case the roof of the skull is exostosed.

Notes.—A widespread genus ranging from Bolivia to Panama.

Habrahyla Goin

1961 *Habrahyla* Goin, Copeia, 1961, p. 62, type *Habrahyla eiselti* Goin. *Diagnosis.*—A small tree frog with vertical pupils; tongue bilobed and free behind; rounded sacral diapophyses; unapposable thumbs; cranial derm free of skull and roof of skull not exostosed; teeth present only on the upper jaws and vomers; palpebral membrane not reticulate; webbing reduced on hands and feet.

Notes.—Known at present from a single species, *Habrahyla eiselti*, from Brazil.

Hemiphractus Wagler

1828 *Hemiphractus* Wagler, Isis von Oken, p. 743, type *Rana scutata* Spix. *Diagnosis.*—A well developed helmet but with derm of head not co-ossified with skull; teeth or odontoids present on mandible and palatines; no expanded digital pads; eye closer to tip of snout than to angle of jaw.

Notes.—A single species, *H. scutatus*, occurs in Peru, Ecuador, and Amazonas, Brazil.

Hyla Laurenti

1768 *Hyla* Laurenti, Specimen medicum, exhibens synopsis, Reptilium, p. 32, type *Hyla viridis* Laurenti (designated by Stejneger, 1907, United States National Museum, Bulletin 58, p. 75).

1799 *Calamita* Schneider, Historiae amphibiorum naturalis et literariae, Ienae, fasc. 1, p. 151, type *Calamita arborea*=*Rana arborea* Linnaeus designated by Stejneger, 1907, United States National Museum, Bulletin 58, p. 75).

1814 *Hylaria* Rafinesque, Specchi delle Scienze, Palermo, v. 2, fasc. 7 (substitute for *Hyla*).

1825 *Boana* Gray, Annals Philosophy, n.s., v. 10, p. 214, type *Rana boans* Linnaeus.

1826 *Hylaplesia* Boie, Ferussac's bulletin, sec. 2, Sciences naturelles et de géologie, v. 9, p. 239, type *Hyla punctata* Daudin (designated by Stejneger, 1937, Copeia, p. 139). (preoccupied by *Hylaplesia* Schlegel, 1826=*Dendrobates*.)

1830 *Auletris* Wagler, Naturliches System der Amphibien, p. 201, type (*Rana*) *boans* Linnaeus=*Hyla boans* Daudin (designated by Stejneger, 1907, United States National Museum, Bulletin 58, p. 76).

1830 *Hyas* Wagler, Naturliches System der Amphibien, p. 201, type *Rana arborea* Linnaeus [preoccupied by *Hyas* Leach, 1815 (Crustacea)].

1830 *Hypsiboas* Wagler, Naturliches System der Amphibien, p. 200, type *Hyla palmata* Daudin.

1830 *Phyllodytes* Wagler, Naturliches System der Amphibien, p. 202, type *Hyla luteola* Wied.

- 1830 *Scinax* (or *Scynax*) Wagler, *Natürliches System der Amphibien*, p. 201, type *Hyla aurata* Wied (designated by Stejneger, 1907 United States National Museum, Bulletin, 58, p. 76).
- 1830 *Dendrohyas* Wagler, *Natürliches System der Amphibien*, p. 342 (substitute name for *Hyas*, preoccupied, *vide* Stejneger, 1907, United States National Museum, Bulletin, 58, p. 76).
- 1838 *Litoria* Tschudi, *Memoires Société neuchâteloise des Sciences naturelles, Neuchâtel*, p. 36, type *Litoria freycineti* Tschudi=*Hyla freycineti*.
- 1838 *Lophopus* Tschudi, *Memoires Société neuchâteloise des Sciences naturelles, Neuchâtel*, p. 32, 73, type *Lophopus marmoratus* Tschudi=*Hyla marmorata* Laurenti [preoccupied by *Lophopus* Duméril, 1837, (Polyzoa)].
- 1838 *Ranoidea* Tschudi, *Memoires Société neuchâteloise des Sciences naturelles, Neuchâtel*, p. 35, type *Ranoidea jacksonensis*=*Hyle jacksonensis* (Bibron, MS.).
- 1843 *Dendropsophus* Fitzinger, *Systema reptilium*, fasc. 1, p. 31, type *Hyla frontalis* Daudin.
- 1843 *Dryophytes* Fitzinger, *Systema reptilium*, fasc. 1, p. 31, type *Hyla versicolor* LeConte.
- 1843 *Hypsipsophus* Fitzinger, *Systema reptilium*, fasc. 1, p. 30, type *Hyla xerophylla* Duméril and Bibron.
- 1843 *Lobipes* Fitzinger, *Systema reptilium*, fasc. 1, p. 30, type *Hyla palmata* Daudin [preoccupied by *Lobipes* Cuvier, 1817 (Aves)].
- 1843 *Osteopilus* Fitzinger, *Systema reptilium*, fasc. 1, p. 30, type *Trachycephalus marmoratus* Bibron 1841=*Hyla septentrionalis* Boulenger 1882, nec *Hyla marmorata* Laurenti, 1876.
- 1843 *Phyllobius* Fitzinger, *Systema reptilium*, p. 30, type *Hyla albomarginata* Spix [preoccupied by *Phyllobius*, Schonherr, 1824 (Coleoptera)].
- 1856 *Centrotelma* Burmeister, *Erläuterungen zur Fauna Brasiliens*, enthaltend Abbildungen und ausführliche Beschreibungen neuer oder ungenügend bekannter Thier-Arten, p. 97, type *Hyla infulata* Wied.
- 1856 *Hylomedusa* Burmeister, *Erläuterungen zur Fauna Brasiliens*, enthaltend Abbildungen und ausführliche Beschreibungen neuer oder ungenügend bekannter Thier-Arten, p. 102, type *Hyla crepitans* Wied.
- 1858 *Pelodryas* Günther, *Catalogue Batrachia Salientia*, p. 119, type *Pelodryas caeruleus* White=*Hyla caeruleus*.
- 1862 *Hylella* Reinhart and Lütken, *Videnskabelige Meddelelser fra den naturhistoriske Forening, Kjoenhavn*, pt. 1, p. 199, type *Hylella tenera* Reinhart and Lütken (designated by Smith and Taylor, 1948, United States National Museum, Bulletin 194, p. 76).
- 1867 *Cinclidium* Cope, *Journal of the Academy of Natural Sciences of Philadelphia*, n.s., v. 6, pt. 2, p. 200, type *Cinclidium granulatum* Cope [preoccupied by *Cinclidium* Blyth, 1842 (Aves)].
- 1867 *Chirodryas* Kerfenstein, *Nachrichten Gesellschaft der Wissenschaften, Göttingen*, p. 358, type *Chirodryas raniformis* Kerfenstein=*Hyla raniformis*.
- 1870 *Cincloscopus* Cope, *American Philosophical Society, Proceedings*, v. 11, no. 84, p. 554, footnote (substitute name for *Cinclidium* Cope, preoccupied).

- 1870 *Cophomantis* Peters, Monatsberichte Akademie Wissenschaft, Berlin, p. 650, type *Cophomantis punctillata* Peters.
- 1879 *Exerodonta* Brocchi, Bulletin de la Société philomathique de Paris, ser. 7, v. 3, p. 20, type *Exerodonta sumichrasti* Brocchi.
- 1885 *Epedaphus* Cope, American Philosophical Society, Proceedings, v. 22, pt. 4, no. 120, p. 383, type *Hyla gratiosa* LeConte.
- 1893 *Fanchonia* Werner, Zoologischer Anzeiger, p. 82, type *Fanchonia elegans* Werner=*Hyla aurea* (Lesson).
- 1899 *Hyliola* Mocquard, Nouvelles Archives du Muséum d'Histoire Naturelle, Paris, ser. 4, v. 1, p. 337, type *Hyla regilla* Baird and Girard (designated by Stejneger, 1907, United States Museum, Bulletin 58, p. 76).
- 1926 *Güntheria* Miranda-Ribeiro, Arquivos Museu Nacional, Rio de Janeiro, v. 27, p. 67, type *Hyla dasynotus* Günther.
- 1927 *Palmatorappia* Ahl, Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin, 1926, p. 113, type *Hylella solomonis* Sternfeld=*Hyla atropunctata* Van Kampen.
- 1945 *Pseudohyla* Andersson, Arkiv. för Zoologi, v. 37A, no. 2, p. 86, type *Pseudohyla nigrogrisea* Andersson.
- 1953 *Limnaoedus* Mittleman and List, Copeia, 1953, p. 83, type *Hylodes ocularis* Holbrook, 1838.

Diagnosis. — Without teeth on mandible, palatine, or parasphenoid; vocal pouch in male, if present, median and subgular; pupil horizontal; sacral diapophysis well expanded in all except some of the larger forms; cranial derm not fused with skull except in a few West Indian species; neither eggs nor young carried on back of female; tympanum present and usually fairly distinct, tongue fairly well fused behind; a well developed quadratojugal; no backward projecting process on ischium; no well developed ventrolateral gland along each side.

Note. — The largest genus in the family, it contains several hundred known species, and is nearly world-wide in distribution, being absent from the Arctic and Subarctic regions and from much of Africa.

Hyloscirtus Peters

- 1882 *Hylonomus* Peters, Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin, I, p. 107, type *Hylonomus bogotensis* Peters [preoccupied by *Hylonomus* Dawson, 1860 (Amphibia, Stegocephalia)].
- 1882 *Hyloscirtus* Peters, Sitzungsberichte der Gesellschaft naturforschender Freunde, Berlin, I, p. 127, type *Hylonomus bogotensis* Peters (substitute name for *Hylonomus*, preoccupied).

Diagnosis. — No tympanum or external evidence of ear; rounded sacral diapophyses; a median subgular vocal pouch in male; vomerine teeth behind level of choanae. Life history unknown.

Notes. — I have seen three specimens of this genus. I hold with Dr. Dunn (1944) that it is a valid genus of hylid frogs but its relationships are, and must remain, questionable until more data are available. Perhaps it is related to *Cryptobatrachus*. At the present time *bogotensis* is the only known species.

Nototheca Bokermann

- 1920 *Coelonotus* Miranda-Ribeiro, Revista Museu Paulista, v. 12, p. 327, type *Coelonotus fissilis* Miranda-Ribeiro [preoccupied by *Coelonotus* Peters, 1855 (Pisces)].
- 1950 *Nototheca* Bokermann, Papéis Avulsos, v. 9, no. 14, p. 217, type *Coelonotus fissilis* Miranda-Ribeiro (substitute for *Coelonotus* Miranda-Ribeiro, preoccupied).

Diagnosis.—Rather small frogs (circa 30 mm.) with a pouch on back of female in the form of a longitudinal, slit-like, trough; derm of head not co-ossified with skull. The slit-like pouch and the small size distinguish this from *Gastrotheca*, while the free derm of the head will separate it from *Flectonotus*.

Notes.—Bokermann (1950:218) includes *fissilis*, *pygmaeum*, and *fitzgeraldi* in this genus.

Nyctimantis Boulenger

- 1882 *Nyctimantis* Boulenger, Catalogue Batrachia Salientia, p. 421, type *Nyctimantis rugiceps* Boulenger.

Diagnosis.—A large hylid with the cranial derm co-ossified with the skull; a vertical pupil; tongue nearly fused behind; without reticulations on palpebral membrane.

Notes.—This handsome frog is known to me by the type series of *rugiceps* in the British Museum and a single specimen from Ecuador in the Museum of Zoology, University of Michigan.

Nyctimystes Stejneger

- 1916 *Nyctimystes* Stejneger, Biological Society of Washington, Proceedings, v. 29, p. 85, type *Nyctimantis papua* Boulenger.

Diagnosis.—Pupil vertical; cranial derm not fused to skull; palpebral membrane reticulate; tongue not extensively free behind.

Notes.—A recent revision of this group (Zweifel, 1958) lists 14 species. The genus is restricted to the Papuan region, from the Moluccas to the Louisiade Archipelago.

Osteocephalus Steindachner

- 1862 *Osteocephalus* Steindachner, Archivo per la Zoologia l'Anatomia e la Fisiologia, Geneva, v. 2, fasc. 1, p. 77, type *Osteocephalus taurinus* Steindachner (not of Fitzinger, 1843, a *nomen nudum*).

- 1926 *Garbaena* Miranda-Ribeiro, Arquivos Museu Nacional, Rio de Janeiro, v. 27, p. 95, type *Garbaena garbei* Miranda-Ribeiro.

Diagnosis.—Males with paired vocal pouches, one at each angle of the jaw; derm of head not co-ossified with skull but roof of skull exostosed.

Notes.—There are perhaps eight or ten species of this genus in South America. Certainly *taurinus*, *britti*, *leprieuri*, *buckleyi* and *pearsoni* belong here. *O. planiceps* is surely a synonym of *leprieuri* and I believe that *garbei* is as well. The status of such forms as *macrotis*, *riopastazae*, and *depressa* has not yet been settled.

Phrynohyas Fitzinger

- 1843 *Phrynohyas* Fitzinger, Systema reptilium, p. 30, type *Hyla zonata*.

- 1862 *Scytotis* Cope, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 14, p. 354, type *Scytotis hebes* Cope.

Diagnosis. — Skin of head not co-ossified with skull and roof of skull not exostosed; skin of nape and shoulder region thickened; no postorbital process on frontoparietal bone; vomerine teeth forming two short, transverse series between the small, rounded choanae; male with paired, lateral vocal pouches. *Notes.* — In his recent (1956) revision, Duellman lists seven species in this genus, three of which (*hebes*, *ingens* and *zonata*) are South American. Probably another half dozen South American species now masquerading as *Hyla* also belong here.

Phyllomedusa Wagler

- 1830 *Phyllomedusa* Wagler, *Natürliches System der Amphibien*, München, p. 201, type *Rana bicolor* Boddaert.
 1866 *Pithecopus* Cope, *Journal of the Academy of Natural Sciences of Philadelphia*, ser. 2, v. 6, p. 86, type *Hyla hypochondrialis* Daudin.
 1872 *Hylomantis* Peters, *Monatsberichte Akademie Wissenschaft*, Berlin, p. 772, type *Hylomantis aspera* Peters.
 1923 *Phrynomedusa* Miranda-Ribeiro, *Boletim Museu Nacional*, Rio de Janeiro, p. 3, type *Phrynomedusa fimbriata* Miranda-Ribeiro.
 1926 *Bradymedusa* Miranda-Ribeiro, *Arquivos Museu Nacional*, Rio de Janeiro, p. 104, type *Bradymedusa moschata* Miranda-Ribeiro = *Phyllomedusa rohdei* Mertens.

Diagnosis. — Vertical pupil; palpebral membrane not reticulate; tongue extensively free behind; webbing reduced on feet; in most of the species the first toe longer than the second (if it is shorter it is accompanied by reduced webbing on the feet). Because of the lack of palpebral reticulation *Agalychnis calcarifer* will probably key out to this genus in the accompanying key but the webbing on its feet and its short first toe should serve to place it as an *Agalychnis*.

Notes. — There are about twenty-five species of *Phyllomedusa*. The genus ranges from Central America to Argentina. A recent revision (Funkhouser, 1957) includes *Agalychnis* in *Phyllomedusa* but the arguments for doing so do not to me seem convincing.

Plectrohyla Brocchi

- 1877 *Plectrohyla* Brocchi, *Bulletin de la Société philomathique de Paris*, ser. 7, v. 1, p. 93, type *Plectrohyla guatemalensis* Brocchi.
 1877 *Cauphias* Brocchi, *Bulletin de la Société philomathique de Paris*, ser. 7, v. 1, p. 129, type *Plectrohyla guatemalensis* Brocchi.

Diagnosis. — No quadratojugal; a well developed spine on the prepollex; teeth not present on palatines or parasphenoid.

Notes. — This genus of about a half dozen species is distributed in Mexico and Central America. While a number of South American representatives of the genus *Hyla* have a well developed, projecting spine on the prepollex, they differ from *Plectrohyla* in having well developed quadratojugals.

Pseudacris Fitzinger

- 1843 *Pseudacris* Fitzinger, *Systema reptilium*, fasc. 1, *Amblyglossae*, p. 31, type *Rana nigrita* LeConte.
 1854 *Chorophilus* Baird, *Proceedings of the Academy of Natural Sciences of Philadelphia*, v. 7, p. 59, type *Rana nigrita* LeConte.

- 1854 *Helocaetes* Baird, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 7, p. 59, type *Pseudacris triseriata* (designated by Schmidt, 1953, Check list of North American amphibians and reptiles, ed. 6, p. 73.)

Diagnosis.—More or less terrestrial hylids with reduced digital disks; very reduced webs on toes; sacral diapophyses only moderately expanded.

Notes.—A North American genus with a dozen nominal forms, species and subspecies. I have never seen the neotropical species *cuzcanus* Cope which is at times referred to this genus (Lutz, 1950: 634). It may prove to be an *Aplastodiscus*.

Pternohyla Boulenger

- 1882 *Pternohyla* Boulenger, Annals and magazine of natural history, ser. 5, v. 10, p. 326, type *Pternohyla fodiens* Boulenger.

Diagnosis.—Cranial derm fused to skull; a secondary bony growth forming a low ridge along edge of upper jaw; no teeth on mandibles, palatines or parasphenoid.

Notes.—A single species, *fodiens*, known from Mexico and Arizona.

Ptychohyla Taylor

- 1944 *Ptychohyla* Taylor, Kansas University Science Bulletin, v. 30, p. 41, type *Ptychohyla adipiventris* Taylor.

Diagnosis.—The characters of *Hyla* but with a well developed ventrolateral gland along each side.

Notes.—A small genus with but four valid species. The genus is restricted to Central America and southern Mexico.

Smilisca Cope

- 1865 *Smilisca* Cope, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 17, p. 194, type *Smilisca daulinia* Cope=*Hyla baudini* Duméril and Bibron.

Diagnosis.—A pair of postorbital projections on the frontoparietal bones; *M. depressor mandibulae* with two distinct heads, one of which originates on the squamosal; vocal sac in male subgular with a tendency toward pairing.

Notes.—The genus ranges from Mexico to Colombia and includes four species: *baudini*, *gabbi*, *phaeota*, and *wellmanorum*.

Tetraprion Stejneger and Test

- 1891 *Tetraprion* Stejneger and Test, United States National Museum, Proceedings, v. 14, p. 167, type *Tetraprion jordani* Stejneger and Test.

Diagnosis.—Derm of head co-ossified with skull and skull strongly exostosed; teeth on vomers, palatines, and parasphenoid; no teeth on mandible.

Notes.—The single species, *jordani*, is the only one known for this rare genus.

Trachycephalus Tschudi

- 1838 *Trachycephalus* Tschudi, Memoires Société neuchâtelaise des Sciences naturelles, Neuchâtel, v. 2, p. 33, 74, type *Trachycephalus nigromaculatus* Tschudi.

Diagnosis.—Paired vocal pouches in male, one at each angle of jaw; cranial derm co-ossified with skull.

Notes.—The several forms described in this genus are probably nothing but individual variations of a single, somewhat variable species, *nigromaculatus*. See Cochran, 1954 (1955), p. 208.

Tripriion Cope

- 1865 *Pharyngodon* Cope, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 17, p. 193, type *Pharyngodon petasatus* Cope [pre-occupied by *Pharyngodon* Diesing 1861 (Helminthes)].
- 1866 *Tripriion* Cope, Proceedings of the Academy of Natural Sciences of Philadelphia, v. 18, p. 127, type *Pharyngodon petasatus* Cope (substitute for *Pharyngodon* Cope, preoccupied).

Diagnosis. — Pupil vertical; teeth on parasphenoid but not palatines; cranial derm fused to skull; a well developed proboscis; canthal ridges fused to form a median ridge.

Notes. — A single species, *petasatus*, occurs in northern Yucatan.

KEY TO THE GENERA OF HYLID FROGS

- | | | |
|-----|--|-----------------------|
| 1 | Teeth or odontoids present on mandible..... | 2 |
| 1' | No teeth or odontoids present on mandible..... | 5 |
| 2 | No parasphenoid teeth..... | 3 |
| 2' | Parasphenoid teeth present..... | <i>Amphodus</i> |
| 3 | Palatine teeth present..... | 4 |
| 3' | No palatine teeth..... | <i>Amphignathodon</i> |
| 4 | Expanded digital pads present; eye placed midway between snout and angle of jaw..... | <i>Cerathyla</i> |
| 4' | No expanded digital pads present; eye placed closer to tip of snout than to angle of jaw..... | <i>Hemiphractus</i> |
| 5 | Palatine teeth present..... | 6 |
| 5' | No palatine teeth..... | 9 |
| 6 | Parasphenoid teeth present..... | 8 |
| 6' | No parasphenoid teeth..... | 7 |
| 7 | Snout produced into proboscis; canthal ridges fusing into median ridge anteriorly | <i>Aparasphenodon</i> |
| 7' | Snout not produced into projecting proboscis; canthal ridges not fusing anteriorly | <i>Trachycephalus</i> |
| 8 | Tip of snout notched and not projecting in the form of a strongly developed proboscis; canthal ridges not confluent anteriorly.... | <i>Tetrapriion</i> |
| 8' | Tip of snout unnotched and produced anteriorly in the form of a well developed proboscis; canthal ridges confluent anteriorly.... | <i>Diaglena</i> |
| 9 | Pupil vertical | 10 |
| 9' | Pupil horizontal | 15 |
| 10 | Derm of head co-ossified with skull..... | 11 |
| 10' | Derm of head not co-ossified with skull..... | 12 |
| 11 | Snout produced into a projecting proboscis; parasphenoid teeth present | <i>Tripriion</i> |
| 11' | Snout not produced into a projecting proboscis; no parasphenoid teeth | <i>Nyctimantis</i> |
| 12 | Palpebral membrane reticulate..... | 14 |
| 12' | Palpebral membrane not reticulate..... | 13 |

- 13 Tongue distinctly bilobed behind; sacral diapophyses rounded; bright markings, if present, on surfaces exposed while frog is at rest..... *Habrahyla*
- 13' Tongue indistinctly or very weakly bilobed behind; sacral diapophyses expanded; bright markings, if present, on surfaces concealed while frog is at rest..... *Phyllomedusa*
- 14 Tongue extensively free behind; eye often red in life..... *Agalychnis*
- 14' Tongue only partially free behind; eye not red in life..... *Nyctimystes*
- 15 Vocal pouches paired in male..... 16
- 15' Vocal pouches not paired in male..... 19
- 16 Vocal pouches at angle of jaws..... 17
- 16' Vocal pouches subgular..... *Smilisca*
- 17 Cranial derm free of skull..... 18
- 17' Cranial derm co-ossified with skull..... *Corythomantis*
- 18 Cranial derm thin; roof of skull exostosed..... *Osteocephalus*
- 18' Cranial derm thickened and somewhat glandular; roof of skull smooth..... *Phrynohyas*
- 19 Eggs carried on back of female..... 20
- 19' Eggs not carried on back of female..... 24
- 20 Eggs in a definite pouch on the back 21
- 20' Eggs may be placed in a basin on the back or each may rest in its individual depression but no definite pouch present..... 23
- 21 Pouch with transparent walls and a longitudinal dorsal slit-like opening 22
- 21' Pouch walls not transparent; opening either puckered or slit-like but the opening posterior rather than dorsal..... *Gastrotheca*
- 22 Cranial derm co-ossified with skull..... *Flectonotus*
- 22' Cranial derm free of skull..... *Nototheca*
- 23 Each egg in individual depression, no basin-like structure; thighs somewhat thick for a hylid, more *Rana*-like..... *Cryptobatrachus*
- 23' Each egg may or may not be in an individual depression but entire egg mass in a basin-like structure; thighs not thickened and not *Rana*-like *Fritziana*
- 24 Cranial derm free of skull, or if co-ossified then posterior margin of skull not margined with a row of high, conical, erect, bony spines..... 25
- 24' Cranial derm co-ossified with skull and posterior margin of skull margined with a row of high, conical, erect, bony spines..... *Anotheca*
- 25 Digital disks greatly reduced, but little wider than digits..... 26
- 25' Digital disks not reduced, distinctly wider than digits..... 28
- 26 Webs on feet reduced..... 27
- 26' Webs not reduced on feet, extending nearly to tips of toes..... *Acris*
- 27 Snout-vent length greater than 35 mm., South American.... *Aplastodiscus*
- 27' Snout-vent length 35 mm. or less, North American..... *Pseudacris*

- 28 Cranial derm not co-ossified with skull, or if so fused then secondary bony growth not forming a low ridge along edge of upper jaw..... 29
- 28' Cranial derm co-ossified with skull and secondary bony growth forming a low ridge along edge of upper jaw..... *Pternohyla*
- 29 No projecting rudiment of a pollex, or if such is present there is also a quadratojugal bone present..... 30
- 29' A projecting rudiment of a pollex, but no quadratojugal bone present *Plectrohyla*
- 30 Without a large ventrolateral gland along each side..... 31
- 30' A large ventrolateral gland along each side..... *Ptychohyla*
- 31 Tympanum generally present with the sacral diapophyses generally expanded 32
- 31' Tympanum indistinct or absent and sacral diapophyses rounded *Hyloscirtus*
- 32 Males with vocal pouch on the posterior margin of throat region made of a number of longitudinal folds bounded anteriorly and posteriorly by transverse folds; snout pointed and projecting; a posteriorly projecting process on the ischium..... *Dryomelictes*
- 32' Males without vocal sac as described above and without posteriorly projecting process on ischium..... *Hyla*

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POPULAR SUMMARY

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Synopsis of the Genera of Hylid Frogs

by Coleman J. Goin

July 14, 1961

The tree frogs (Family Hylidae) comprise a large, widely distributed group. The group as a whole is a very successful one and includes some three hundred different species. Many of the species have developed rather bizarre life histories. South America seems to be a center of evolution of the family.

This article is the first attempt in recent decades to define all of the groups (genera) within the family. Thirty-three genera are recognized in this synopsis and each is defined. For each genus a statement is made concerning its relative size and distribution.

Additional copies of this publication may be obtained from Carnegie Museum, Pittsburgh 13, Pa., for .35 each, plus .15 for postage and handling (and .02 tax for Pennsylvania residents only).



ART. 3. ON A COLLECTION OF ARABIAN REPTILES

By GEORG HAAS

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In 1955 Carnegie Museum received a collection of 58 specimens of amphibians and reptiles from Saudi Arabia. This collection was made by Mr. Robert S. Mathews who was in Arabia on other duties. When I visited Carnegie Museum in the summer of 1959 Mr. Neil D. Richmond called my attention to this collection and also permitted me to borrow a portion of this material for additional study. This relatively small but extremely interesting collection represents 20 species (1 frog, 7 snakes, and 12 lizards) and the slightly known nature of the herpetofauna of this region is indicated by the fact that two new species and possibly one or two new subspecies are represented.

I wish to express my gratitude to Dr. Carl Gans, Buffalo, for his kind help in restyling this manuscript and to Mr. Neil Richmond for supplying the scale counts of the snakes, the illustrations of the two new forms (Fig. 1-2), arranging the material for publication, and reading proof.

The following localities, all in Saudi Arabia, are represented in the collection. They may be found in Haas (1957, p. 49) and on the "Southwest Asia" sheet of the National Geographic Society's map series (June 1952, v. 101, no. 6).

Abqaiq, Al Hasa District.

Badanah, (Approximately 31° 30' N. lat., 41° 30' E. long., on Aramco Pipeline, near Iraq border.)

Dahanah Desert, (This is Ad Dahna District on map.)

Damman, Al Hasa District.

Dhahran, Al Hasa District.

Dik'kan, (Probably Dukhan, on western Qatar Peninsula.)

Hofuf, Al Hasa District.

Jafura Desert, southeast Al Hasa District, southwest of the Qatar Peninsula.

Qatif Oasis, Al Hasa District.

Rub' Al Khali, with Mr. Mathew's note "approximately 23° N-41° E."

Rumah, "Dahana Desert" is shown on map in Ad Dahna District, near the Arma Plateau.

Salwa, Al Hasa District, near base of the Qatar Peninsula.

Wadi Arar, north of Badanah. (The Pipeline crosses the Wadi at Badanah.)

ACCOUNT OF SPECIES

Rana ridibunda ridibunda Pallas

8 (C.M. 33547-48); Al Hasa, 3 miles E. of Hofuf; April 20, 1953.

(C.M. 33544-46); Al Hasa, NW. corner of Qatif Oasis; February 1953.

(C.M. 33549-51); Al Hasa, Qatif Oasis; May 14, 1954.

All collected by R. S. Mathews.

Eryx jayakari Boulenger

2 (C.M. 33507); Al Hasa, Abqaiq; March 1951. Malaria Control Technician.

(C.M. 33527); Al Hasa, Dhahran; July 12, 1953. R. S. Mathews.

The details of scutellation and measurements for these and the other snakes in this collection are given in Table 1.

Coluber ventromaculatus Gray

4 (C.M. 33508-09); Al Hasa, Abqaiq; March 1951. Malaria Control Technician.

C.M. 33541-42); Al Hasa, 2 miles S. of Qatif; July 5, 1954. R. S. Mathews.

Eirenis arabica sp. nov.

Type.—(C.M. 33511) An adult male from Saudi Arabia, Al Hasa District, Abqaiq; March 1951. R. S. Mathews.

Diagnosis.—This single specimen represents a new species of the genus *Eirenis* similar in habitus and color pattern to *E. coronella* sensu Schmidt 1939, (= *E. fasciata* auct.). It differs from *E. coronella* by a narrow head, by the more tapering frontal, which is longer and not shorter than the snout, and by the presence of only six instead of seven supralabials. The reduced number of supralabials, strongly constricted nuchal band, and the shape of the frontal serve to distinguish this form from *E. coronella fraseri* Schmidt.

Description.—The frontal shield is longer than snout, but shorter than the parietal; the loreal is somewhat longer than high, much smaller than the preocular and ventrally is in contact with the second and third supralabials. It has one preocular and two postoculars. The temporals are 1+1+2. The second temporal is two-thirds the length of the first, and only half as high.

There are six supralabials of which the last is very much enlarged. The third and fourth supralabials contact the eye, the latter has a contact three times as long as the former. The fifth supralabial contacts the lower postocular and the first, angularly bent temporal. The sixth supralabial is much the largest and highest of the series, dorsally in contact with the first, second, and lower third temporals.

There are eight infralabials. The posterior chin shields are much narrower and only two-thirds the length of the anterior. The anterior pair of chin shields has a long sagittal contact, while the posterior pair is separated by an azygous scale.

Dorsal scales smooth, 15-15-13; ventrals 147; anal divided; caudals 52/52.

There is a broad, dark-brown transverse nuchal band; this fuses with a dark blotch on the head and is followed caudad by a series of brown saddles, 43 anterior to the cloaca and 18 on the tail. The anterior ventrals and extensive parts of the gular area are covered by dark scales with yellowish posterior margins. The third and fourth supralabials are completely dark and this dark bar continues onto the third and fourth infralabials. The posterior infralabials and both pairs of chin shields are well marked with dark. Measurements; snout to vent, 178 mm.; tail 58 mm.

Discussion.—The presence of 15 rather than 17 or 19 rows of dorsal scales effectively distinguishes this species from most forms described in the genus. From *E. persica* (Anderson) including the synonyms *walteri* (Boettger), *machmahoni* Wall, *zebrina* Wall and *angusticeps* Boulenger it is easily distinguished by the much lower ventral count, coloration, and the less slender habitus. This species appears closest to *E. coronella* although the high number of ventrals in this one *arabicus* ♂ 147, suggests that this character may also be distinctive, for comparison a series of 33 ♂ *coronella* from Israel have ventral counts ranging from 128 to 141.

Lytorhynchus diadema arabicus Haas

1 ♂ (C.M. 33510); Saudi Arabia, Al Hasa, Abqaiq; March 1951. Malaria Control Technician.

The specimen agrees in habitus, coloration and in the high ventral count with the slender Arabian subspecies. It has 193 ventrals, 47/48 subcaudals, a divided anal and 15 scale rows at midbody. There are 45 dark, widely spaced cross-bars to the vent and 13 much paler transverse markings on the tail. Snout-vent + tail length is 356+60 mm.

Hydrophis spiralis (Shaw)

1 (C.M. 33539); 6 miles from Dhahran; January 1953; R. S. Mathews.

According to Mr. Mathews's note this specimen was found in a boat on the beach. It is so badly dried and wrinkled that it is difficult to obtain accurate scale counts. There is but one anterior temporal. The scales are smooth and imbricated. There are 47 black rings on the body and four on the tail, with the tip of the tail black. The black rings are widest dorsally, and extend completely around the body. On the back, the area between the bands is uniform dusky gray while the sides and venter are light as though they may have been white or yellow in life.

Hydrophis cyanocinctus Daudin

1 (C.M. 33540); 5 miles S. of Dhahran, Half Moon Bay; April 1952. R. S. Mathews.

This is a well preserved specimen. It has two anterior temporals, the dorsal scales are more or less hexagonal with a strong central tubercle. Some of the scales on the anterior part of the body have two tubercles. The scales are weakly imbricate. The preanals are not enlarged. Dorsal surface uniformly dark brown, on the sides the remains of 29 dorsal bars can be seen on the body and four or five more on the tail. These appear as dark points of the dorsal color extending about half way down the sides. Under side light tan in preservation.

Aspis cerastes (Linnaeus)

2 (C.M. 33512); Al Hasa, Abqaiq; March 1951. Malaria Control Technician.
(C.M. 33543); Al Hasa, SE. Jafura Desert; April 1954.

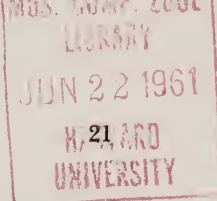
Both the above lack superciliary "horns".

Ceramodactylus sp.

1 ♂ (C.M. 33520); Saudi Arabia, Al Hasa, Southeast Jafura Desert; April 1954. R. S. Mathews.

The characters of this specimen fall between those of the two closely related species *C. doriae* and *C. major*. Since some previously discussed specimens of the same genus (Haas, 1956: 308; 1957: 58) also showed such intermediate conditions, the revision of this species group seems advisable. Without entering in a discussion of the exact determination of the specimen at hand, the data are given in the following paragraph.

Measurements. Head and body, 50 mm.; tail, 56 mm. In accordance with *C. major*, this specimen has the inner nasals widely separated by an azygous, rather big, scale and has a rather high labial count, namely 17 supralabials and 16 infralabials; the naris does not share the first labial, as it is surrounded by three nasals and the rostral. The specimen agrees with both species in ques-



tion in possessing only two widely separated femoral pores in the ventral pelvic region. Distal traces of a slightly enlarged ventromedian row of subdigital, trihedral scales, strictly serially arranged smooth dorsal scales contrasting with wider and more rugose ventrals, separate the specimen from *C. major* as determined in the first description by Parker, 1930.

The condition of the scales surrounding the naris in a population of *C. doriae* from southern Israel is constant in all the eight specimens seen: the naris shares the first supralabial. In the same series, however, four specimens have inner nasals in contact behind the rostral, two have them separated by a large azygous shield and two separated by a small azygous shield. In this series from Israel the labial counts are 13 supralabials and 11 infralabials, well in agreement with *C. doriae* but much below the figure given above for the Arabian specimen. This short list of characters shows the peculiar intermediate position of the specimen under discussion; more material from this same area might permit some decision as to the status of this interesting specimen. Perhaps both "species" of *Ceramodactylus* will eventually be revealed as a single form with a few characters exhibiting clinal variation. However, not enough material has been collected in this area, and a final decision should be postponed.

Gymnodactylus scaber (Heyden)

- 1 Juv. (C.M. 33525); Saudi Arabia, Al Hasa, Dahran; July 1954. R. S. Mathews.

Alsophylax blanfordii (Strauch)

- 1 ♂ (C.M. 33532); Saudi Arabia, near Badanah; late May 1954. C. Rock.
1 Juv. (C.M. 33537); Saudi Arabia, Dahana Desert; November 14, 1952. R. S. Mathews.
1 ♀ (C.M. 33521); Saudi Arabia, Al Hasa, SE. Jafura Desert; April 1954. R. S. Mathews.

The male of the series (C.M. 33532) has 11 preanal pores (*A. tuberculatus* has 7-8) and the typically flattened, elongated head of *A. blanfordii*, but lacks the keeled and mucronate ventral scale of the latter form. The transverse subdigital lamellae are denticulated in all three specimens. In the female (C.M. 33521) the dorsal trihedral scales are considerably smaller and more widely spaced than in the male. There is a striking sexual size difference of the enlarged occipital tubercles.

Stenodactylus stenodactylus (Lichtenstein)

- 1 Adult (C.M. 33536) Dahana Desert; November 14, 1952; R. S. Mathews.

Hemidactylus persicus Anderson

- 1 Juv. (C.M. 33526); Al Hasa, Dahran; September 1954. R. S. Mathews.

Phrynocephalus nejdensis macropeltis Haas

- 2 Adults, sex ♂, ♀ (C.M. 33523-24); Al Hasa, near Dahran; July 5, 1954. R. S. Mathews.

Both specimens agree in all details with the description of this subspecies (Haas 1957).

Varanus griseus Daudin

- 1 Juv. (C.M. 33538) "Just out of Rub' Al Khali, approximately 23° N. 51° E."

Diplometopon zarudnyi Nikolsky

5 (C.M. 33503-06); Al Hasa, Abqaiq; March 1951. Malaria Control Technician.

(C.M. 33522); Al Hasa, S. of Salwa; May 16, 1954. R. S. Mathews.

These specimens have been described in detail and figured by Gans (1960).

Acanthodactylus scutellatus ssp.?

1 ♂ (C.M. 33531); Saudi Arabia, near Badanah; late May 1954. C. Rock.

This single specimen shows a mixture of controversial characters. It has been compared with *A. scutellatus hardyi* Haas (1957) and *A. scutellatus* ssp. of Parker (1931), the first from Hirmas Station, Saudi Arabia, and the second from southeast of the Arabian Peninsula (Rub' al Khali Desert). Other *scutellatus* material from Arabia has not been described. All the subspecies of *scutellatus* mentioned in Boulenger (1921) are from N. Africa, with the exception of the typical form, which ranges through Egypt, the Sinaitic Peninsula, Palestine, Mesopotamia (Basra) and to In Salah in the Algerian Sahara.

The specimen under discussion has 12 ventrals, except for a few rows at midbody with 14, and differs otherwise from *hardyi* in the following points. The fourth supraocular is not entirely broken up into small granules, but separated from the third by a single series of minute granules, the innermost being larger, wedge shaped, and laterally in contact with the elongate, elliptical fourth supraocular. Dorsal scales rather bluntly keeled, sharper in the posterodorsal region. No enlarged gular scales bordering on chin shields (very characteristic of *A. s. scutellatus*.) Prefrontals rather elongate, nasal suture very short. Temporal granules smooth. The eye region in males from Israel protrudes from the main frontal level; in the Arabian specimen, no such protrusion can be seen, instead the frontal area is rather flattened.

In the following table, the available data concerning Parker's specimen are compared with the specimen at hand and *hardyi*.

	C.M. 33539	<i>Hardyi</i> (Type)	Parker's data 1931
Snout/vent	68 mm.	65 mm.	
Scales across midbody, all.....	72	72	
Collar scales	9	7-8	
Ventral, imperfect longitudinal series	12-14	12	
Number of gulars to collar.....	31	31	37
Transversal series of ventrals.....	31	30	
Femoral pores	17-17	very indistinct ♀	23-24
Lamellae under fourth toe.....	20	25	27
Supralabials in front of eye.....	5	5	4

The few comparable data show quite a number of different criteria in the three *scutellatus* specimens from different parts of the vast Arabian Peninsula. It would be too early to name this new specimen; more material would enable us to get a clearer opinion about the Arabian forms of the *scutellatus* group, to which all three undoubtedly belong.

Acanthodactylus cantoris schmidtii Haas

1 ♂ (C.M. 33519); Saudi Arabia, Al Hasa, SE. Jafura Desert; April 1954. R. S. Mathews.

1 ♂ (C.M. 33528); 1 ♀ (C.M. 33529); 1 Juv. (C.M. 33530); Saudi Arabia, east side of Dahana, near Rumah; March 20-21, 1953. R. S. Mathews.

1 ♀ (C.M. 33533); Saudi Arabia, Qatif Oasis; March 6, 1953. R. S. Mathews.

All these specimens conform well with the subspecies *c. schmidtii*. The biggest male (C.M. 33528) measures almost 90 mm. from snout to vent, has 25/24 femoral pores in a continuous, V-shaped series meeting in front of the vent. The biggest female (C.M. 33529) measures (snout to vent) 70 mm.

Eremias adramitana Boulenger

1 ♂ (C.M. 33535; Saudi Arabia, Dikkan; November 15, 1952. R. S. Mathews.

Eremias guttulata guttulata (Lichtenstein)

1 ♀ (C.M. 33534); Saudi Arabia, near Badanah, Wadi Arar; February 21, 1953. R. S. Mathews.

The specimen has a very large occipital in contact with the interparietal shield, and deeply intercalated into the parietals. The occipital forms a straight posterior contour together with the parietals. There are two large transparent scales with black margins in each lower eyelid.

Scincus richmondi sp. nov.

Type.— (C.M. 33515); A mature female, collected in Saudi Arabia, Al Hasa District, SE. Jafura Desert; April 1954. R. S. Mathews.

Paratypes.— Five additional specimens with the same data as the type are available. These include three males, one female and one juvenile (C.M. 33513-14, C.M. 33516-18).

Diagnosis.— A *Scincus* very similar in habitus to *S. philbyi* Schmidt but possessing paired prefrontals and 30 scale rows around the middle of the body instead of 26 in *philbyi*, which has 28 at a point slightly posterior of the middle. The frontal is elongate, the interparietal rhombic, almost squarish, loreals three.

Description of the Type.— Ear opening very obscure, overlapped by a slightly enlarged, posteriorly fringed scale, ending in four digitations, two scales from rictal areas. Snout in proportions of *S. philbyi*. Internasal in contact with the slightly asymmetrical paired prefrontals. Frontal much more elongate and tapering posteriorly than in *philbyi* (length: width index being 1.7 against 1.5 in *philbyi*). Six supraoculars, four supraciliaries, the second being the shortest, the first much longer than the others. Frontoparietals as in *philbyi*; interparietal as broad as long, rhombic, but widest transverse diameter closer to the rostral end, and not narrow-elongate as in *philbyi*. The pineal eye is visible near the posterior end of the shield as a dark dot. Two right and three left nuchals in contact with the respective parietals; three loreals (not two), first as long as wide, second and third very elongate; nasal much smaller than supranasal, nostril elongate; four suboculars; temporals, two-two. Eight upper, 7/8 lower labials. Thirty scale rows across the middle of the body and posterior of the middle; two median postmentals, the anterior being slightly narrower than the mental; the posterior being five times as deep (sagittally) as the anterior. One pair of large anal plates. Ten lamellae under fourth toe; 57 ventrals from anals to a point opposite rectus oris; same number of dorsals from point opposite of thighs to interparietal. The specimen has on the left side six, on the right side seven, vertical mark-

ings, which are much higher than long, three vertical, but only one to two horizontally following scales being involved.

The following differences from *philbyi* may be stressed, as found in all six specimens. Thirty scale rows across midbody against 26; the much elongate frontal; the almost squarish interparietal which is elongate in *philbyi*; the 2/3 arrangement of the nuchals against a 2/2 arrangement; three loreals against two. The extremely wide posterior postmental has been found in the type only.

Discussion.—The only species with similar characters (obliterated ear opening), six supraoculars, and a possibly corresponding scale count would be, according to Boulenger, *Scincus arenarius* with 28 or 30 scales across the middle of the body, but this otherwise sketchily defined species has only been recorded from Sind, very far away from our locality. *Scincus mitranus* from southern Arabia, having 29-30 scales across the middle of the body, has only five supraoculars. In the above mentioned *S. arenarius* the dorsal scales should be perfectly smooth; in *richmondi*, a faint longitudinal striation is visible. The differences from *S. philbyi* have been mentioned above, except that it should be noted that *philbyi* may also have paired prefrontals as in the series discussed by Haas (1957) although the type and 11 paratypes have but a single prefrontal.

This new species is distinguished from *arabicus* Schmidt by the specially long contact of the paired frontoparietals, in *arabicus* these two shields are entirely separated by the interparietal which extends forward to contact the frontal. The parietals are paired in *richmondi* but are broken up into small transverse scales in *arabicus*. Geographically, the two species are widely separated with *arabicus* in Hadhramaut, and *richmondi* in the Jafura Desert, Al Hasa District.

This new form is the eighth species of *Scincus* to be described from Saudi Arabia. These may be distinguished by the following key.

Key to Arabian Species of the Genus *Scincus*

- A. Five supraoculars
 - B. No lateral spots, 26 scale rows.....*gasparetti*
 - BB. Lateral spots present
 - C. Ten lateral spots, 29-30 scale rows around body.....*mitranus*
 - CC. Two or three lateral spots, 22-24 scale rows.....*meccensis*
- AA. Six supraoculars
 - B. Thirty scale rows around body
 - C. Frontoparietals separated by interparietal, 2 loreals.....*arabicus*
 - CC. Frontoparietals broadly in contact, 3 loreals.....*richmondi*
 - BB. 24-28 scale rows
 - C. Nine lateral spots, 24-26 scale rows.....*muscatensis*
 - CC. 0-6 lateral spots, 24-26 scale rows
 - D. Ear opening obscure, 0-6 lateral spots.....*philbyi*
 - DD. Ear opening visible, 4 lateral spots.....*deserti*

TABLE I. SCUTELLATION OF SNAKES IN THIS COLLECTION

	C.M. number	Sex	Scale rows	Ven- trals	Cau- dals	Upper labials	Lower labials	Total length in mm.	Tail in mm.
<i>Eryx</i>									
<i>jayakari</i>	33507	♂	39-43-31	178	21	10	13	240	17
" "	33527	♂	45-51-33	177	21	10	13	445	28
<i>Coluber</i>									
<i>ventromaculatus</i>	33508	♂	19-19-13	204	91	9	9	674	179
" "	33509	juv.	19-19-13	207	119	9	9	334	83
" "	33541	♂	19-19-13	204	100	**	**	1082	275
" "	33542	♂	19-19-13	206	96	9	9	744	209
<i>Hydrophis</i>									
<i>spiralis</i>	33539	♂	27-33*	1812	134
<i>cyanocinctus</i>	33540	♂	29-40*	312	43	7	7	980	85
<i>Aspis cerastes</i>	33512	juv.	29-31-25	149	33	14	15	379	39
" "	33543	♀	23-37-25	166	39	14	16	718	81

* These counts are of the minimum and maximum number.

** Head damaged.

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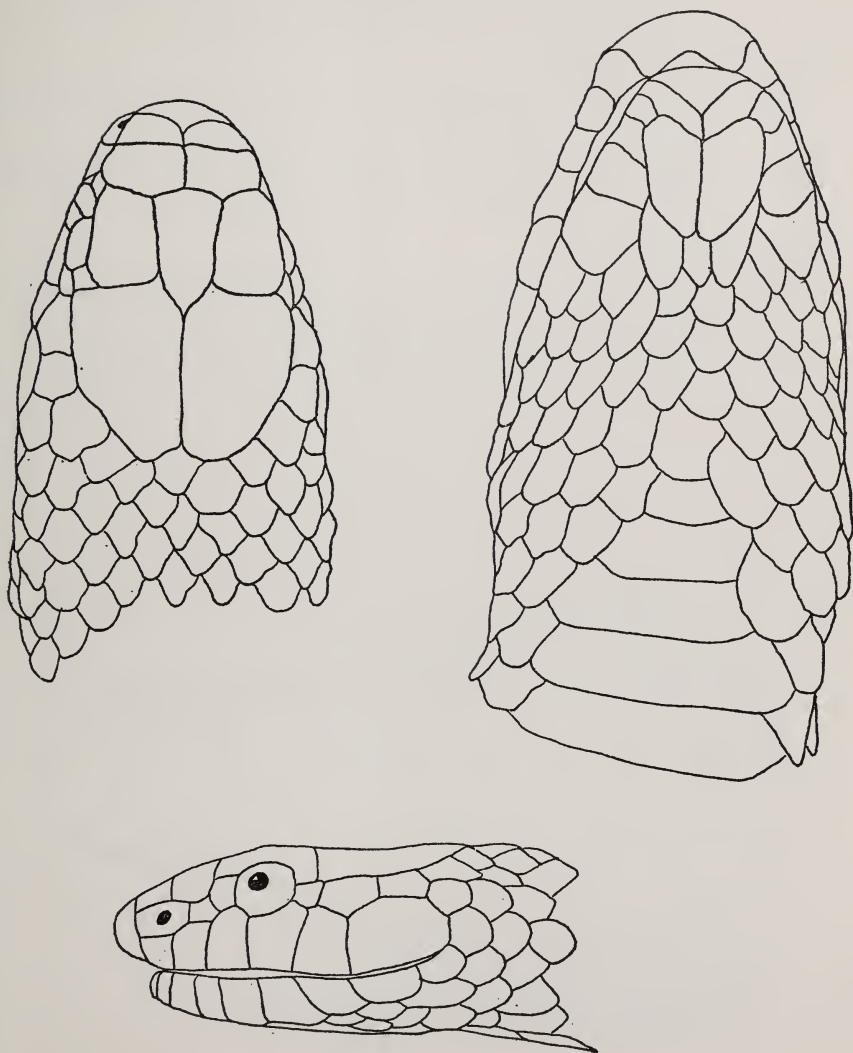


Fig. 1. *Eirenis arabica* Haas, new species. Dorsal, ventral and lateral views of head of C.M. 33511, type. Drawn from photographs and not the same scale

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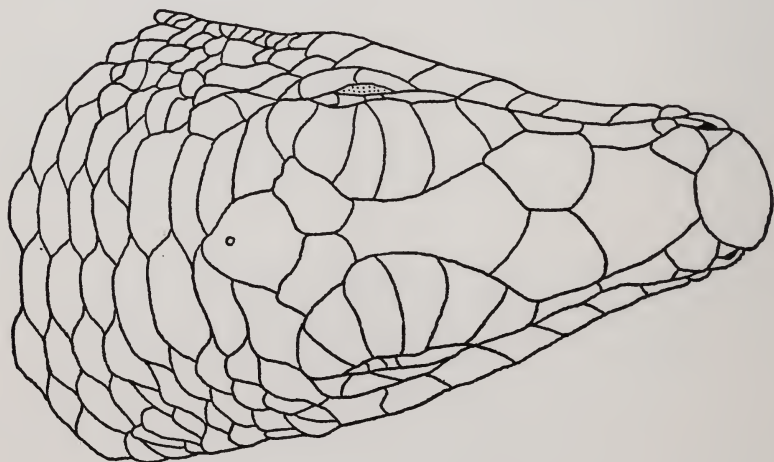
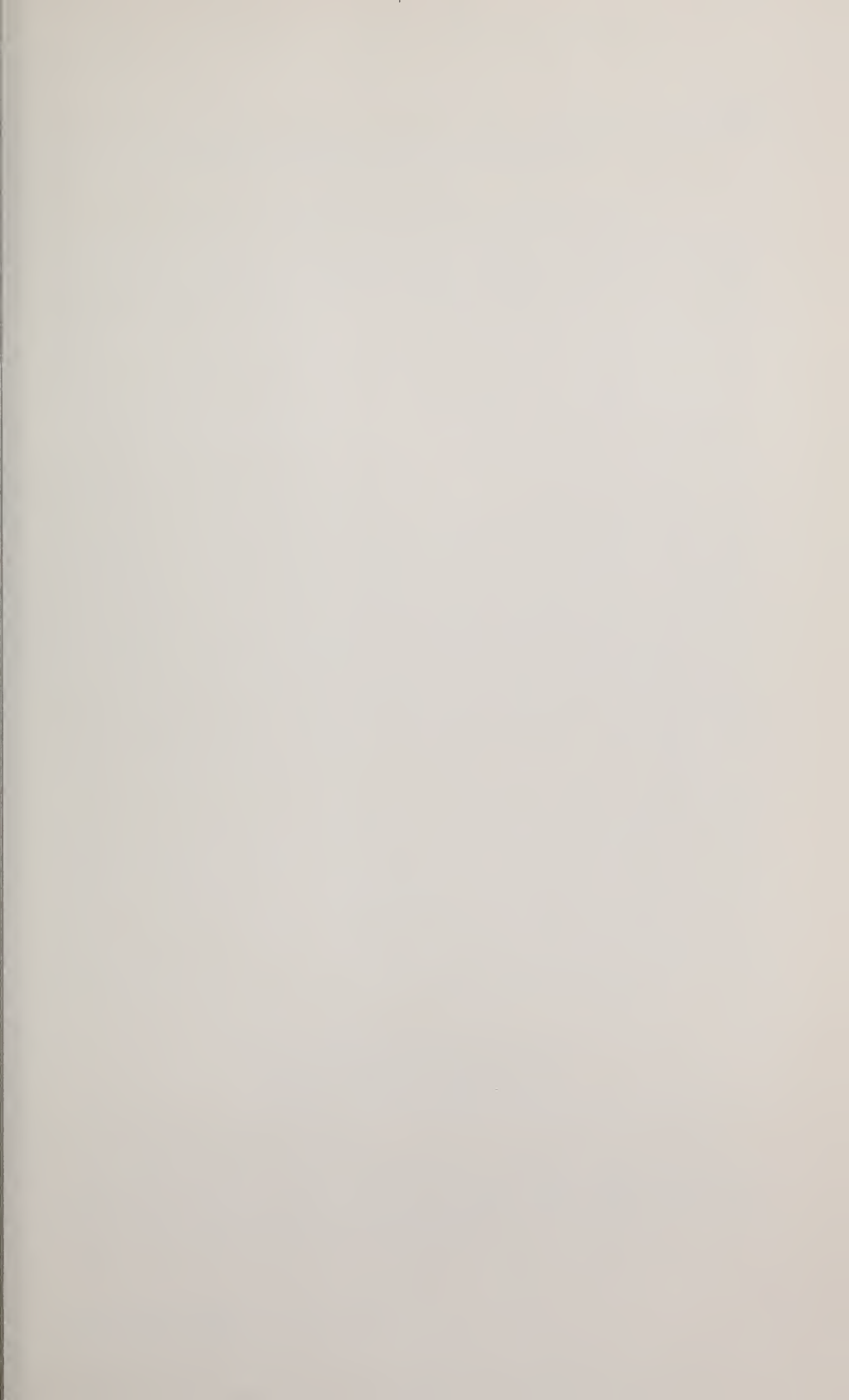


Fig. 2. *Scincus richmondi* Haas, new species. Dorsal view of head of C.M. 33515, type. Drawn from photograph



ART. 4. SCOLECODONTS FROM WELL SAMPLES OF THE
DUNDEE, DEVONIAN OF MICHIGAN

By E. R. ELLER

Curator of Geology and Invertebrate Paleontology

Through the courtesy of the late Dr. W. B. Wilson of the Gulf Oil Corporation, a small cut from well samples at Gulf No. 1 Sam, Section 27-15 N-4E, Kawkawlin Field, Michigan, was made available for study. There were 32 samples in the suite and they were taken from 2860½ feet to 2937½ feet below the surface. The object of this examination was to determine if scolecodonts, fossil polychaete annelid jaws, were present in oil and gas well samples, and if so, could they be used for correlation purposes.

Scolecodonts were found in nearly every sample of this suite, although in many cases they were too damaged to be of use. It is remarkable, when the broken-up nature of the well sample is considered and that often only a teaspoonful of material was available, that any usable specimens were recovered. The jaws were obtained from the limestone cuttings by dissolving the material in a five per cent. solution of hydrochloric acid and collecting the insoluble residue in sieves up to 100 mesh. Most of the specimens were found in the samples between 2889 and 2898½ feet below the surface. In addition to scolecodonts, clear and iron-stained quartz grains, pyrite, and considerable selenite appeared as residue in certain samples. At the 2937½ foot level a teaspoonful of material produced over a hundred specimens of very small size. They averaged from one-third to one-tenth smaller than those found in other samples. Most specimens appeared to be adults yet were less than one-tenth of a millimeter in length. The size of the jaws may be due to an adverse physical-chemical condition of the environment. Considerable more selenite and pyrite were present in the residue than in other samples.

The samples are recorded in the log as Dundee limestone, the top being at 2865 feet. Since the scolecodonts of the Dundee limestone have not been studied it was necessary to examine various outcrops of Dundee and determine the fauna for comparison. Preliminary studies show only one species, *Lumbriconereites cooperi*, a long-range form, to be common to the well samples and to the outcrops of the Dundee. Until further studies of other horizons are made, a definite geologic determination from evidence presented by the scolecodonts can not be given to the well samples. It would seem, however, from these studies that scolecodonts, similar to other micro-fossils, could be used to identify the rocks penetrated by the drilling bit.

DESCRIPTION OF SPECIES

Genus LUMBRICONEREITES Ehlers, 1868

Lumbriconereites cooperi? Eller

Maxilla I. Plate 1, Fig. 1, 2, 3

Lumbriconereites cooperi Eller, 1938. Annals of the Carnegie Museum, v. 27, p. 275-277, Plate 28, Fig. 5, 6

The figured specimen measures 0.62 mm. in length. There is a close resemblance between this form and *Lumbriconereites cooperi* Eller (1938). Both have the same angular appearance and proportions. The difference is mostly in the number and character of the denticles.

Lumbriconereites crispus sp. nov.

Maxilla I. Plate 1, Fig. 4, 5, 6, 4a, 4b, 4c

The jaw is very small, narrow, and elongate. The figured specimen measures 0.21 mm. in length and 0.08 mm. in width at the widest part. Along the inner margin a series of nine blunt, triangular shaped denticles extends nearly the full length of the jaw. The denticles are large in comparison to the size of the jaw. The first denticle or fang is directed forward and is longer and not as wide as the other denticles. The second tooth is small and the remaining ones increase in size to the mid-area and then decrease in size to the posterior extremity. The outer margin is nearly straight to the midpoint where it bulges slightly and then curves gently inward to form a small bight and shank. On the upper surface a long, narrow, deep fossa occupies most of the jaw. The margins of the fossa are thick and well rounded. The under surface is wavy or irregularly convex and concave.

Except for the position of the shank and the type of denticles *Oeononites major* Hinde (1882) is similar to *Lumbriconereites crispus*. The left jaw of *Lumbriconereites cooperi* Eller (1938) resembles *Lumbriconereites crispus* slightly. They differ in the position and size of the shank and bight and the type of denticles.

Lumbriconereites cruciatus sp. nov.

Maxilla I. Plate 1, Fig. 7, 8

The jaw is large, elongate, and irregular in shape. The figured specimen measures 0.99 mm. in length and 0.38 mm. in width. A series of thirteen or fourteen irregularly shaped denticles extends nearly to the wide, well rounded posterior end. The fang is long, pointed, forward directed and is twisted out of alinement with the other denticles. The second denticle is smaller and is followed by three or four teeth that are perpendicular to the inner margin or point in a backward direction. The remaining denticles are smaller but irregular in size and are pointed in a backward direction. At about the midpoint on the outer margin is a well rounded, long but not very wide shank. A deep fossa occupies about three-fourths of the upper side of the jaw. The margins of the fossa are well rounded and thickened.

Although *Lumbriconereites cruciatus* fits well in this genus, it does not correspond very closely to any other species.

Lumbriconereites celsus sp. nov.

Maxilla I. Plate 1, Fig. 9, 10, 11, 9a, 10a, 11a

The jaw is small, elongate and not very wide. The figured specimen measures only 0.16 mm. in length and 0.06 mm. in width at the widest part. Along the nearly straight inner margin a series of about seven triangular, sharp-pointed, backward-directed denticles extend nearly to the pointed posterior extremity. The fang is fairly thin, pointed and hooked. Both the first and second denticles are elevated out of alinement with the other teeth. The remaining denticles are nearly uniform in size, increasing only slightly at the mid-area. The denticles are rather large for the size of the jaw. The outer margin is irregularly curved and forms a small rounded shank, which posteriorly curves gently inward to form the narrow end of the jaw. On the

inner margin a narrow, angular, flange-like projection extends the full length of the jaw. A shallow fossa occupies the posterior half of the jaw including the shank. The margins of the fossa are thickened and rounded. The under side of the jaw is slightly concave from the denticles to the lateral margins.

While *Lumbriconereites celsus* has many characteristics found in various forms described under the genus, it does not correspond very closely to any other particular species.

***Lumbriconereites claviformis* sp. nov.**

Maxila I. Plate 1, Fig. 12, 13, 14

The jaw is elongate, wide anteriorly, and narrow at the posterior end. The figured specimen measures 0.86 mm. in length and 0.29 mm. in width at the widest part. A series of 15 sharp, backward directed denticles extends nearly to the posterior extremity. The first seven denticles, including the fang, are large and uniform in size. The remaining teeth are small and decrease in size only slightly to the posterior end. A short, rounded shank situated anterior to the mid-area of the jaw forms a shallow bight with the inner margin. A large fossa occupies most of the upper surface of the jaw. The margins of the fossa are thick and rounded. The under surface is flattened or slightly concave in the area between the shank and the denticles.

There is a slight similarity between the right jaw of *Lumbriconereites cooperi* Eller (1938) and *Lumbriconereites claviformis*. They differ mostly in the shape of the anterior area and in the character of the shank.

***Lumbriconereites contiguus* sp. nov.**

Maxila I. Plate 1, Fig. 15, 16, 17, 15a

The jaw is small, elongate and the figured specimen measures 0.33 mm. in length and 0.13 mm. in width at the widest part. A series of twelve small blunt denticles extends nearly the full length of the jaw. The first denticle or fang is large and well hooked. The next three or four teeth are directed forward and are contiguous with the fang. These are followed by denticles that gradually swing from a perpendicular position to a backward direction. The denticles increase in size to about the midpoint and then become smaller to the rounded posterior end. A wide angular shank is present at the mid-area of the jaw. The small crescent-shaped bight posterior to the shank is shallow but well defined. A large deep fossa occupies about two-thirds of the upper surface of the jaw. The margins of the fossa are thickened and well-rounded. The inner margin of the fossa is rather straight and then forms an angle with the curved anterior margin and fang. The under surface adjacent to the denticles is flattened or slightly concave.

There is a general similarity between *Lumbriconereites johnsoni* Eller (1945) and *Lumbriconereites contiguus*. They differ in the shape of the fossa and character of the denticles.

***Lumbriconereites compactilis* sp. nov.**

Maxilla I. Plate 1, Fig. 18, 19, 20, 21, 21a

The jaw is minute, narrow and elongate. The figured specimen measures 0.22 mm. in length and 0.08 mm. in width. Along the nearly straight inner

margin a series of about twelve conical, backward directed denticles extends to the posterior end. The fang is long, thin, and well hooked. The second denticle is thin, prominent and nearly perpendicular to the margin. The remaining teeth decrease gradually in size to the posterior. From the midpoint to the posterior they become very compact. The outer margin curves slightly inward to form a well rounded shank. The posterior half of the jaw is very narrow, due to a long, shallow, crescent-shaped bight. A deep fossa, wide anteriorly and very narrow posteriorly, occupies the posterior half of the upper side of the jaw. The margins of the fossa are thickened and well rounded. The under side of the jaw is concave adjacent to the denticles but becomes convex near the shank.

There is a similarity between *Lumbriconereites linki* Eller (1945) and *Lumbriconereites compactilis* in general outline, especially the shape of the outer margin and the narrow posterior end. They differ in the shape of the fossa and the character of the denticles.

Genus ARABELLITES Hinde, 1879

***Arabellites commendabilis* sp. nov.**

Maxilla I. Plate 1, Fig. 22, 23

The jaw is large and wide, and terminates in a truncate posterior end. The figured specimen measures 0.95 mm. in length and 0.39 mm. in width. Along the straight inner margin a series of eleven or twelve small, conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. They decrease only slightly in size posteriorly. The sharp-pointed, well hooked fang is more than half the size of the jaw. At the posterior part of the outer margin a narrow shank-like projection forms a sharp notch at the anterior end and then curves gently to the truncated posterior. When viewed from the under side, the shank is convex and forms an irregular groove with the jaw. The upper side of the shank is also convex and forms the outer side of a large fossa. Adjacent to the denticles the fossa is deep but it becomes shallow toward the shank and at the posterior end. The under side of the jaw is irregularly convex and concave.

In outline *Arabellites commendabilis* is similar to a number of forms in the genus. The shank-like projection has not been found in other species. *Arabellites conspicuus* of this fauna (Plate 1, Fig. 24-25) has a shank somewhat similar to *Arabellites commendabilis*. The fossa, however, is completely different.

***Arabellites conspicuus* sp. nov.**

Maxilla I. Plate 1, Fig. 24, 25

The jaw is small, wide, and terminates with a truncate posterior extremity. The figured specimen measures 0.31 mm. in length and 0.15 mm. in width. A series of eight small, conical, sharp-pointed, backward-directed denticles extends the full length of the nearly straight inner margin. The denticles are uniform in size. A conspicuous sharp-pointed, conical, hooked fang is equal in size to about one-half the length of the jaw. At the posterior third of the jaw on the outer margin, a narrow shank-like projection extends to the end of the jaw. It is slightly wider anteriorly and curves inward to become narrow and thickened at the posterior end. There is a well pronounced groove

between the shank and the jaw on the under side. A small fossa, round anteriorly but truncate posteriorly, is located on the upper side of the jaw somewhat forward to the posterior end. The anterior and outer margins of the fossa are thickened and rounded but the posterior margin seems to be thin. The under side of the jaw is highly convex except near the denticles where it is concave. The area posterior to the fossa on the upper side of the jaw is irregularly concave and convex.

Arabellites conspicuus is very similar in its general outline to *Arabellites commendabilis*. They differ in the shape of the shank-like projection, the shape and position of the fossa, and the size of the fang.

Genus STAUROCEPHALITES Hinde, 1879

Staurocephalites cucullus sp. nov.

Maxilla II. Plate 1, Fig. 26, 27

The hood-shaped jaw is large, elongate, wide anteriorly and narrows abruptly at the mid-area to form a narrow, posterior extremity. The figured specimen measures 1.59 mm. in length. On the inner margin a series of 15 sharp-pointed, triangularly shaped, backward-directed denticles extends the full length of the jaw. The first denticle is large and wide especially at the base while the second denticle is small and often minute. Both teeth are usually perpendicular to the surface of the jaw. The remaining denticles tend to bend inward. The third denticle is large and the remaining teeth decrease in size to the posterior end. The anterior margin is broadly rounded, the right outer margin is incurved at about the midpoint, and the outer margins in the posterior half of the jaw are straight and parallel with the denticles. A large, shallow fossa occupies the complete upper side of the jaw. The margins of the fossa are thin but usually not broken.

Staurocephalites nettingi Eller (1945) and *Staurocephalites paquetensis* Eller (1945) are similar to *Staurocephalites cucullus*. They differ in the anterior area and in the arrangement of the denticles. *Staurocephalites cucullus* resembles *Staurocephalites externus* Eller (1944) except for the type and arrangement of the denticles and the width and shape of the right outer margin.

Staurocephalites clivus sp. nov.

Maxilla II. Plate 1, Fig. 28, 29

The jaw is long, subrectangular in shape, with an uneven surface. A series of 15 denticles extends along the inner margin nearly to the posterior extremity. The first four or five denticles are smaller, thinner, and more sharp-pointed than the remaining teeth. All of the denticles are conical and triangular in shape. The denticles are largest at the mid-region and decrease in size posteriorly. The left outer margin is irregularly curved and the surface in the anterior region between the denticles and the margin is highly convex. The adjacent posterior area is flattened. A deep fossa occupies all of the upper side of the jaw. It is narrow posteriorly but widens at the anterior end. The margins of the fossa are irregular, thin, and broken. The described specimen measures 0.76 mm. in length.

Staurocephalites clivus is similar to other species of this genus only in a general way.

Staurocephalites condensus sp. nov.

Maxilla II. Plate 1, Fig. 30

The jaw is elongate and subrectangular in outline. The figured specimen measures 0.38 mm. in length. A series of 15 small, closely spaced, conical, sharp-pointed, backward-directed denticles extends nearly the full length of the inner margin. The anterior end is straight and obliquely truncate to the first small but strongly built denticle. It is followed by three or four minute teeth which gradually increase in size to the mid-area and then decrease in size to the rounded posterior end. The right outer margin is straight in the anterior region and then curves inward to the posterior. The left outer margin is thin and usually broken. Evidence from some specimens suggests that this side of the jaw may have been wide. A deep fossa occupies the full length of the upper side of the jaw. The fossa is wide anteriorly but narrows in the posterior region.

There is a similarity between *Staurocephalites condensus* and *Staurocephalites devinctus* Eller (1946). They have the same obliquely truncate anterior end. The forms differ in the type and arrangement of the denticles and the width of the jaw. *Staurocephalites nettingi* Eller (1945) resembles *Staurocephalites condensus* only in a general way.

Genus OENONITES Hinde, 1879

Oenonites canaliculatus sp. nov.

Maxilla II. Plate 1, Fig. 31, 32, 33, 34, 35, 31a, 32a

The jaw is elongate or narrowly triangular in outline. Specimens measure from 0.11 mm. to about 1.43 mm. in length. A series of 10 to 12 sharp-pointed, triangular-shaped denticles extends about three-quarters the length of the jaw. The first denticle is small but more hooked than the other denticles. The remaining denticles increase in size to about the midpoint and then decrease gradually to the posterior. All denticles are pointed in a backward direction. A large, deep fossa occupies most of the upper side of the jaw. The anterior margin and the margin on the upper side of the fossa are thickened and rounded while the outer margin is thin and often broken. The upper surface of the jaw is depressed or channeled on both sides of the denticles.

Oenonites canaliculatus resembles *Oenonites coggeshalli* Eller (1945) in a general way. They differ in the type and arrangement of the denticles and the shape of the fossa.

Genus PALEOENONITES Eller, 1942

Paleoenonites curvilineatus sp. nov.

Maxilla II. Plate, 2, Fig. 1, 2, 3, 8, 9

The jaw is subtriangular in outline, wide anteriorly and narrow at the blunt, posterior end. The figured specimens measure 0.23 mm. and 0.97 mm. in length. Along the curved inner margin a series of 10 triangular-shaped denticles extends the full length of the jaw. The first denticle or fang is long, conical, and directed slightly forward or is perpendicular to the margin. The second tooth is large and is usually pointed backward. The remaining denticles are sharp to blunt and decrease in size to the posterior extremity. The series of denticles is oblique to the plane of the under surface of the jaw. The outer margin on the upper side is thin, irregular, and usually broken.

It forms a shank with the curved anterior margin. The outer margin on the under side curves outward from the anterior end and then abruptly inward to form a small shank and a broad, crescent-shaped bight. The shank is slightly oblique to the under surface of the jaw. A deep, irregularly shaped fossa occupies most of the upper surface of the jaw. Except for the outer margin on the inner side, the edges of the fossa are thin, irregular and broken.

There is a slight resemblance between *Paleoenonites clinatus* Eller (1945) and *Paleoenonites curvilineatus*. The species differ in the shape of the outer margins and the position and shape of the fossa.

***Paleoenonites cippus* sp. nov.**

Maxilla II. Plate 2, Fig. 4

The jaw is subtriangular in outline and measures 0.25 mm. in length. A series of six conical to triangular, sharp-pointed to blunt denticles occupies the complete outer margin. The conical, sharp-pointed, forward-directed fang is a little larger than the other denticles. The remaining denticles are usually blunt, directed backwards, and uniform in size. The anterior margin is rounded near the fang and then incurves slightly to form a very sharp-pointed, forward-directed shank with the slightly curved outer margin. The posterior end is truncate. On the upper surface a deep, narrow fossa extends the full length of the jaw. The inner margin of the fossa is thickened and well rounded. The upper surface of the jaw between the denticles and inner margin is concave or flattened, while the under surface is generally convex.

Except for some general features, this form is dissimilar to other species of the genus.

***Paleoenonites commodus* sp. nov.**

Maxilla II. Plate 2, Fig. 5, 5a

This complete jaw is narrowly subtriangular in shape. The figured specimen measures 0.21 mm. in length. On the outer margin a series of nine conical, sharp-pointed, backward-directed, denticles extends nearly to the posterior end. The first denticle is slightly larger than the other teeth and tends to point slightly forward. From the anterior, the first few denticles are nearly uniform in size to the posterior. The anterior margin is rounded adjacent to the fang, but incurves slightly to form a very small shank with the outer margin which is curved slightly inward and then recurved to the acute posterior extremity. A narrow, deep fossa occupies about half the width of the jaw and extends nearly its full length. The margins of the fossa are thickened and rounded. The under side of the jaw is irregularly convex, while the narrow area between the fossa and the denticles on the upper side is concave.

Paleoenonites commodus is similar to *Paleoenonites castigatus* Eller (1945). They differ in the curvature of the outer margin, the number of denticles, and the width of the jaw.

***Paleoenonites circulus* sp. nov.**

Maxilla II. Plate 2, Fig. 6, 7

The jaw is small and wide, and the figured specimen measures 0.23 mm. in length and 0.21 mm. in width. The outer margin on the under side is broken in all specimens so that the true width can not be determined; it is

probably greater than the height. On the nearly straight inner margin a series of nine or ten large, conical, sharp-pointed denticles extends to the posterior end. The first denticle is small and usually points in a forward direction. The second denticle is the largest and it is slightly hooked. The remaining denticles are directed slightly backward and decrease uniformly in size to the posterior extremity. The denticles are large in comparison to the size of the jaw and are in an oblique position to the under surface. The outer margin on the under side is curved from the anterior end to form a large shank. In all of the recovered specimens the outer margin on the upper side curves slightly outward to form a small shank-like projection. A large, deep, circular fossa occupies most of the upper side of the jaw. The margins of the fossa are thickened and rounded along the anterior upper sides. The under side of the jaw, adjacent to the denticles is flattened or slightly concave.

This species is not very typical for the genus. There is a slight resemblance between *Paleoenonites henryi* Eller (1945) and *Paleoenonites circulus*. They differ in the character of the denticles and the shape and position of the shank.

***Paleoenonites curtilobus* sp. nov.**

Maxilla II. Plate 2, Fig. 10, 11, 12

The jaw is small, subtriangular in outline and the figured specimens measure 0.29 mm. and 0.39 mm. in length. On the inner margin a series of six or seven fairly large, sharp or blunt, backward-directed denticles extends nearly to the posterior end. The first denticle or fang is large and is a continuation of the rounded anterior margin. The remaining teeth decrease in size to the acute posterior extremity. The outer margins are curved and extend to form broad but short-lobed shanks. On the under side, the outer margin is irregular and probably broken while the margin on the upper side is thickened and rounded. A large fossa occupies the upper side of the jaw. An area adjacent to the denticles on the upper side of the jaw is concave while the under side is convex.

In a general way, *Paleoenonites curtilobus* is similar to *Paleoenonites davisae* Eller (1945) and *Paleoenonites latissimus* Eller (1942). They differ in the shape of the outer margin on the upper side. *Paleoenonites alpenaensis* (Eller) (1938) resembles *Paleoenonites curtilobus* except for the shape of the shank and the character of the denticles.

Genus NEREIDAVUS Grinnel, 1877

***Nereidavus curtidentatus* sp. nov.**

Maxilla I. Plate 2, Fig. 13, 14

The jaw is elongate and narrow, and the figured specimen measures 0.45 mm. in length and 0.13 mm. in width. On the nearly straight inner margin a series of the eight to ten sharp-pointed, conical, backward-directed denticles extends about three-quarters of the length of the jaw. The denticles are short and fairly uniform in size. A large fang is sharp-pointed, hooked, and slightly oblique to the plane of the upper surface. The outer margin is straight and is generally parallel to the inner margin. At about the midpoint along the outer margin a narrow fang or shank-like projection extends to the posterior end. When observed from the under side the projection is flat and forms a groove with the outer margin. The posterior end is indented by a deep,

angular bight which forms a narrow shank with the inner margin. A deep irregularly shaped fossa occupies the posterior end of the upper side of the jaw. It extends into the shank. The margins of the fossa are thickened and rounded. The under side of the jaw is flattened or slightly concave while the upper side is convex.

Nereidavus curtidentatus is similar to the left jaw of *Nereidavus harbisonae* Eller (1941) and to *Nereidavus ontarioensis* Stauffer (1939). They differ in the shape of the fossa and posterior end, the projection on the outer margin, and the character of the denticles.

Genus EUNICITES Ehlers, 1868

Eunicites confirmatus sp. nov.

Maxilla IV or V. Plate 2, Fig. 15, 16

The jaw is small, wedge-shaped, having the anterior and posterior margins parallel. The figured specimen measures 0.09 mm. in length. The jaw has a small single curved denticle forming nearly a straight line with the anterior margin. The inner margin is slightly indented by a shallow bight that forms a small shank with the posterior margin. A large fossa occupies most of the upper side of the jaw. The margins of the fossa are very thick and well rounded. The under side of the jaw is slightly concave except at the posterior margin which is convex.

This species is slightly similar to *Eunicites compressus* Eller (1945). They differ in the shape of the fossa and the position of the margins. There is a possibility that this jaw might be a forceps.

Eunicites capax sp. nov.

Maxilla IV or V. Plate 2, Fig. 17

The jaw is an irregular cone-shaped, straight, sharp-pointed denticle which widens abruptly to form a large round base. The figured specimen measures 0.23 mm. in width and 0.39 mm. in length. On the upper side a round, capacious fossa occupies most of the wide part of the jaw. The margin of the fossa is thin and may be broken. Adjacent to the posterior end the sides of the jaw are slightly flattened and angular in appearance.

Eunicites capax is only to a small degree similar to *Arabellites ? conus* Eller (1938) and *Eunicites compressus* Eller (1945). They differ in the shape of the fossa and width of the denticle.

Eunicites conicus sp. nov.

Maxilla V. Plate 2, Fig. 18

The conical shaped jaw consists of a single, narrow, slightly curved, denticle which widens to a truncate base. The figured specimen measures 0.27 mm. in length and 0.13 mm. in width. A nearly round fossa is situated on the upper side of the jaw. The margins of the fossa are slightly thickened and rounded. The under side of the jaw at the posterior end is flattened.

Eunicites conicus does not resemble very closely any other described species.

Eunicites clarus sp. nov.

Maxilla V. Plate 2, Fig. 19, 19a

The jaw is a small, single denticle, extending from a narrow, subtriangular base. The figured specimen measures 0.13 mm. in width and 0.14 mm. in length. The fang is conical, blunt, and curves slightly backwards. The outer

margins are curved and form small, but distinct, sharp-pointed shanks with the anterior margins. All of the outer side of the jaw is occupied by a narrow fossa. The margins of the fossa are slightly thickened and rounded. The jaw is highly convex but is flattened at the acute posterior extremity.

This form is similar to *Arabellites uncinatus* Hinde (1882) and *Eunicites cavus* Eller (1945). They differ in the shape and position of the fossa and the presence of the small shanks at the anterior end of the outer margins.

***Eunicites conoideus* sp. nov.**

Maxilla V. Plate 2, Fig. 20

The jaw is a single, nearly conical, sharp-pointed, backward-directed denticle that extends nearly at a right angle from a curved, subtriangular base. The figured specimen measures 0.27 mm. in width and 0.19 mm. in length. A shallow fossa occupies the complete outer side of the jaw. The margins of the fossa are irregular but not thin or broken. The denticle, situated near the posterior end of the jaw, is slightly flattened near its base.

While this form does not correspond very closely to any fossil species it is very similar to a number of modern types.

***Eunicites consimilis* sp. nov.**

Maxilla V. Plate 2, Fig. 21, 21a

The jaw consists of a single, large, conical, sharp-pointed, backward-directed denticle or fang that extends nearly at right angles from the anterior end of a small, curved, subtriangular base. The figured specimen measures 0.16 mm. in length and 0.32 mm. in width. A shallow fossa occupies the complete outer side of the jaw. The margins of the fossa are rounded and thickened.

Eunicites consimilis does not compare closely with any fossil forms but it is very like the fifth maxilla of many modern species.

***Eunicites catastomus* sp. nov.**

Maxilla I or V. Plate 2, Fig. 22, 23

The jaw or forceps is long, narrow, curved, sharp-pointed and flattened at the base. The figured specimens measure 0.32 mm. and 0.56 mm. in length and 0.08 mm. and 0.18 mm. in width. The posterior margin is deeply indented by a crescent-shaped gap which forms narrow shanks with the lateral margins. A narrow fossa occupies the complete posterior margin of the jaw.

It is difficult to determine whether this form is a forceps or a fifth maxilla. Many modern species have forceps of this sort with carriers attached to the posterior end. *Eunicites catastomus* does not correspond closely enough to other species to warrant comparison.

Genus LEODICITES Eller, 1940

***Leodicites confragosus* sp. nov.**

Maxilla II. Plate 2, Fig. 24, 25, 26

The jaw is narrow, subtriangular, and the figured specimen measures 0.31 mm. in length and 0.14 mm. in width. A series of 11 or 12 sharp-pointed, triangularly shaped, backward-directed teeth extends nearly the full length of the slightly curved to straight inner margin. The first denticle is small, slightly hooked and may point forward. It is followed by a large tooth and then one that may be minute. The remaining denticles increase in size to

the mid-area and then decrease in size to the acute posterior end. The anterior margin is gently rounded from the first denticle to a small notch where it becomes a narrow, sharp-pointed shank. A small crescent-shaped bight on the outer margin forms the posterior margin of the shank. On the outer side a deep, narrow fossa extends nearly the full length of the jaw. The margins of the fossa are thickened and rounded. Both the upper and under surfaces are uneven.

Leodicites reimanni Eller (1941) *Leodicites exilis* Eller (1945) *Paulinites paranaensis* Lange (1947), and *Leodicites crassimarginatus* are similar to *Leodicites confragosus* in a general way. They differ in the shape and arrangement of the denticles, the width of the jaw, or the shape and size of the fossa and shank.

***Leodicites crassimarginatus* sp. nov.**

Maxilla II. Plate 2, Fig. 27, 28, 29

The jaw is subtriangular in outline, narrow anteriorly, and tapers to an acute posterior end. On the inner margin a series of 11 or 12 blunt, triangular-shaped, backward-directed denticles extends nearly to the end of the jaw. When viewed from the side the first denticle, which is thin, appears to be larger than the second, but actually it is smaller. The denticles increase in size to the posterior. The rounded anterior margin becomes straight or slightly incurved to form a thin, sharp-pointed shank. A deep crescent-shaped bight is present on the inner margin. On the upper side of the jaw a deep, narrow, fossa extends nearly the full length of the jaw. The margins of the fossa especially at the anterior are thickened and rounded. The upper surface of the jaw is slightly concave adjacent to the denticles. The figured specimen measures 0.56 mm. in length.

Leodicites crassimarginatus is similar to other forms of this genus in a general way. There is a slight resemblance between *Leodicites exilis* Eller (1945) and *Leodicites crassimarginatus*. *Paulinites paranaensis* Lange (1947) and *Leodicites reimanni* Eller (1941), which are specifically the same, are like *Leodicites crassimarginatus* except for the type and arrangement of the denticles and the width of the jaw.

Genus UNGULITES Stauffer, 1933

***Ungulites? chilalloeus* sp. nov.**

Maxilla I. Plate 2, Fig. 30, 31, 32

The jaw is elongate and subtriangular in shape. The figured specimen measures 0.49 mm. in length. A large slightly hooked fang and two rows of minute denticles of seven each are present on the inner margin. The fang measures 0.24 mm. in length or nearly half the length of the jaw. It is conical or slightly angular in shape. The two rows of denticles on the under side are conical, sharp-pointed, and perpendicular to the margins. The under side of the jaw is concave adjacent to each row of denticles but convex in the mid-area. A large, deep fossa occupies most of the upper side of the jaw. The posterior end of the jaw seems to be broken but probably not too much is missing in the described specimen.

A jaw having two rows of denticles is uncommon, hard to explain, and difficult to place in a genus. The writer is not acquainted with any recent forms of this type. *Staurocephalites bijugus* Eller (1945) has two rows of

denticles that may, however, be two articulated jaws. No seam was definitely detected between the rows of teeth and there was no partition in the fossa. *Ungulites chilalloeus* is an altogether different type and there is no indication of it being anything but a single jaw. For the present time it is being placed in the genus *Ungulites* because when viewed from one side it has a prominent tooth or fang, succeeded by a series of small denticles, similar to several described species.

Genus ANISOCERASITES Eller, 1955

Anisocerasites cultidaclylus sp. nov.

Maxilla III or IV. Plate 2, Fig. 33

The jaw is small and subtriangular in outline. The figured specimen measures 0.18 mm. in length and 0.23 mm. in width. Along the inner margin a series of eight, conical, sharp-pointed denticles extends the full length of the jaw. The denticles can be considered rather large when compared to the size of the jaw. The first two denticles are small and point in a forward direction. The third denticle is large and straight. The remaining, backward-directed, denticles decrease in size to the posterior end. On the upper side, a deep, triangularly shaped fossa occupies the full length of the jaw. The inner margin is thickened and rounded and is situated very close to the denticles. The outer margin curves inward to form a sharp-pointed shank with the thin wide posterior end.

There is a similarity between *Anisocerasites cultidaclylus* and *Anisocerasites caudagallus* except for the number and arrangement of the denticles and the under surface of the jaws. *Anisocerasites tanaodus* Eller (1938) has general characteristics like those of *Anisocerasites cultidaclylus*.

Anisocerasites convexus sp. nov.

Maxilla III or IV. Plate 2, Fig. 34, 35

The jaw is small, subrectangular in outline. The figured specimen measures 0.17 mm. in length and 0.15 mm. in width. A series of four, conical, sharp-pointed, denticles extends along the inner margin. The first denticle is small and is followed by a large medial one that could be considered as a fang. The next denticle is small and the last one is nearly as large as the second or medial tooth. Most of the denticles are perpendicular to the jaw or may point in a forward direction. A large, deep, fossa occupies the upper side of the jaw. The margins of the fossa are slightly thickened and rounded. The anterior margin is straight and forms an angularly shaped shank and bight with the inner margin. The upper side of the jaw is concave while the under side is arched.

Anisocerasites convexus corresponds to the genus except that the last denticle is large. In other species described under this genus the denticles have become smaller on each side of the large medial tooth.

Anisocerasites caudagallus sp. nov.

Maxilla III or IV. Plate 2, Fig. 36, 37, 36a, 37a

The jaw is very small, subtriangular in outline, and wider than long. The figured specimen measures 0.09 mm. in length and 0.12 mm. in width. Along the inner margin a series of six sharp-pointed, triangularly shaped denticles extends the full length of the jaw. The first denticle is small and points

forward while the second is large, fang-like, and is directed backwards. The remaining denticles decrease in size to the posterior end. A large triangular fossa occupies the upper side of the jaw. The inner margin of the fossa is straight and thickened. The outer and posterior margins are thin and curved inward to form a narrow shank. The under side of the jaw is convex except at the posterior end. The denticles seem to extend into the body of the jaw forming a series of ridges and valleys especially at the anterior area.

There is a similarity in shape between *Anisocerasites caudagallus* and *Anisocerasites tanaodus* (Eller) (1938).

***Anisocerasites conjunctus* sp. nov.**

Maxilla III or IV. Plate 2, Fig. 38, 39

The jaw is wedge-shaped and the figured specimen measures 0.16 mm. in length and about 0.35 mm. in width. Most of the jaw consists of a large, conical sharp-pointed, slightly hooked, medial tooth or fang. It measures about 0.22 mm. in length. A small, sharp-pointed, closely adhering denticle occurs on each side of the medial tooth. The anterior margin curves slightly as a continuation of the fang to form a narrow shank with the deeply indented outer margins. A fossa occupies all of the outer side of the jaw. The margins of the fossa are thin and broken.

Anisocerasites conjunctus is similar to *Ungulites tridentatus* Stauffer (1933) in the number and arrangement of the denticles. They differ in the size of the fang and the shape of the outer side of the jaw.

Genus MARLENEITES Eller, 1945

***Marleneites constrictus* sp. nov.**

Maxilla II or III. Plate 2, Fig. 40

The jaw is elongate, constricted or narrow, and tapers gently to rounded ends. The figured specimen measures 0.33 mm. in length. On the convex lower surface a series of 12 or 13 conical, sharp-pointed, slightly hooked denticles extends the full length of the jaw. The denticles are fairly uniform in size except at the posterior where the last two or three decrease in size rapidly and become minute. The inner margins are parallel. A large, deep, narrow fossa occupies the complete upper side of the jaw. The margins of the fossa, including those at the anterior and posterior ends, are thickened and rounded. Between the denticles and the margins the area on the under side of the jaw is slightly depressed.

Marleneites constrictus is similar to *Oenonites marginalus* Eller (1944) and *Marleneites arduus* Eller (1945) in a general way. The forms differ in the width of the jaw, the arrangement of the teeth, and the width of the fossa.

Genus DIOPATRAITES Eller, 1938

***Diopatraites connexus* sp. nov.**

Mandible. Plate 2, Fig. 41, 42

The mandible is long, narrow, and angular in shape. The figured specimen measures 0.55 mm. in length and about 0.12 mm. in width. The frontal plate is small, irregular in outline, and is connected obliquely with the shaft at about a 45° angle. Its upper surface is convex, pointed on the upper side, and bent to such an extent that it is parallel or nearly joined with the upper side of the shaft. In cross-section the shaft is triangular in shape. The sides

are nearly straight and parallel for most of the length, but curve slightly posteriorly to form an acute end. The surface of the shaft between the margins is often concave.

Diopatraites connexus is similar to *Diopatraites fustus* Eller (1942) and *Palaeosigma silurica* Eisenack (1939) except for the size and shape of the plate and shaft.

***Diopatraites corrugatus* sp. nov.**

Mandible. Plate 2, Fig. 43, 44

The length of the mandible is estimated to be about 0.4 mm. The frontal plate is 0.21 mm. in length and is probably about the same length as the shaft. A series of four conical, sharp-pointed denticles or teeth extends the full length of the anterior margin of the plate. The first denticle is large while the other three are small and decrease in size to the inner margin. The plate is set at a slight angle with the shaft. Irregular corrugations or ribs on the upper surface of the plate appear to be continuations of the denticles. The under surface is irregular and a deep groove along the inner margin extends the full length of the mandible.

Diopatraites corrugatus is very similar to *Diopatraites conformis* Eller (1938), Stauffer (1939), and *Nothraites sulcatus* Stauffer (1939). They differ mostly in the number and arrangement of the teeth and the width and configuration of the frontal plate.

***Diopatraites cultellus* sp. nov.**

Mandible. Plate 2, Fig. 45

The mandible is narrow, elongate, angular and blade-like in shape. The figured specimen measures 0.41 mm. in length and 0.13 mm. in width. The inner margin is nearly straight, curving inward slightly at the mid-area. From the posterior the outer margin is slightly incurved to beyond the midpoint where it turns abruptly to form a straight margin with the acute anterior extremity. The shaft at the posterior end is very short and forms a shallow, crescent-shaped indentation. The shaft may be broken but it appears to be complete. The surface of the mandible is flattened except for a ridge that extends from the inner margin to the shaft.

This form if placed in reversed position has the appearance of a carrier. The indented margin, however, has not been found in either recent or fossil specimens. Except for the length of the shaft and the curvature of the outer margin this species is similar to *Diopatraites deplexus* Eller (1946).

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EXPLANATION OF PLATE I

Figures magnified about 28 times. Those followed by an "a" are enlargements of about two times the regular figures.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1-3. *Lumbriconereites cooperi*? Eller
Maxilla I, left jaw (28008).
Under, lateral, and upper sides.
Subsurface level, 2915½ ft., Kawkawlin Field, Michigan.
- Fig. 4-6, 4a-6a. *Lumbriconereites crispus* sp. nov.
Maxilla I, right jaw (28023).
Upper, lateral, and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 7, 8. *Lumbriconereites cruciatus* sp. nov.
Maxilla I, right jaw (28024).
Lateral and upper sides.
Subsurface level, 2915½ ft., Kawkawlin Field, Michigan.
- Fig. 9-11, 9a-11a. *Lumbriconereites celsus* sp. nov.
Maxilla I, right jaw (28025).
Lateral, upper, and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 12-14. *Lumbriconereites claviformis* sp. nov.
Maxilla I, left jaw (28026).
Under, lateral, and upper sides.
Subsurface level, 2889 ft., Kawkawlin Field, Michigan.
- Fig. 15-17, 15a. *Lumbriconereites contiguus* sp. nov.
Maxilla I, left jaw (28027).
Lateral, upper, and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 18-21, 21a. *Lumbriconereites compactitis* sp. nov.
Maxilla I, left jaw (28028).
Upper, lateral, and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 22, 23. *Arabellites commendabilis* sp. nov.
Maxilla I, right jaw (28030).
Under and upper sides.
Subsurface level, 2895 ft., Kawkawlin Field, Michigan.
- Fig. 24, 25. *Arabellites conspicuus* sp. nov.
Maxilla I, right jaw (28031).
Under and upper sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 26, 27. *Staurocephalites cucullus* sp. nov.
Maxilla II, left jaw (28035).
Under and upper sides.
Subsurface level, 2913 ft., Kawkawlin Field, Michigan.
- Fig. 28, 29. *Staurocephalites clivus* sp. nov.
Maxilla II, right jaw (28037).
Under and upper sides.
Subsurface level, 2889 ft., Kawkawlin Field, Michigan.
- Fig. 30. *Staurocephalites condensus* sp. nov.
Maxilla II, left jaw (28038).
Upper side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 31, 32, 31a, 32a. *Oenonites canaliculatus* sp. nov.
Maxilla II, left jaw (28043).
Upper and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 33. *Oenonites canaliculatus* sp. nov.
Maxilla II, left jaw (28041).
Upper side.
Subsurface level, 2913 ft., Kawkawlin Field, Michigan.
- Fig. 34, 35. *Oenonites canaliculatus* sp. nov.
Maxilla II, right jaw (28042).
Under and upper sides.
Subsurface level, 2889 ft., Kawkawlin Field, Michigan.

ANNALS OF CARNEGIE MUSEUM, Vol. 36

Art. 4

Plate 1



EXPLANATION OF PLATE 2

Figures magnified about 28 times. Those followed by an "a" are enlargements of about two times the regular figures.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1-3. *Paleoenonites curvilineatus* sp. nov.
Maxilla II, left jaw (28045).
Under, lateral, and upper sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 4. *Paleoenonites cippus* sp. nov.
Maxilla II, left jaw (28047).
Upper side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 5, 5a. *Paleoenonites commodus* sp. nov.
Maxilla II, left jaw (28049).
Upper side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 6, 7. *Paleoenonites circulus* sp. nov.
Maxilla II, left jaw (28050).
Upper and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 8, 9. *Paleoenonites curvilineatus* sp. nov.
Maxilla II, left jaw (28046).
Under and lateral sides.
Subsurface level, 2895 ft., Kawkawlin Field, Michigan.
- Fig. 10, 11. *Paleoenonites curtilobus* sp. nov.
Maxilla II, left jaw (28051).
Lateral and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 12. *Paleoenonites curtilobus* sp. nov.
Maxilla, right jaw (28057).
Upper side.
Subsurface level, 2934 ft., Kawkawlin Field, Michigan.
- Fig. 13, 14. *Nereidavus curtidentatus* sp. nov.
Maxilla I, left jaw (28058).
Upper and under sides.
Subsurface level, 2965 ft., Kawkawlin Field, Michigan.
- Fig. 15, 16. *Eunicites confirmatus* sp. nov.
Maxilla IV or V, right jaw (28062).
Under and upper sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 17. *Eunicites capax* sp. nov.
Maxilla IV or V, right jaw (28063).
Upper side.
Subsurface level, 2934 ft., Kawkawlin Field, Michigan.
- Fig. 18. *Eunicites conicus* sp. nov.
Maxilla V, right jaw (28064).
Upper side.
Subsurface level, 2918 ft., Kawkawlin Field, Michigan.
- Fig. 19, 19a. *Eunicites clarus* sp. nov.
Maxilla V, right jaw (28066).
Lateral side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 20. *Eunicites conoideus* sp. nov.
Maxilla V, left jaw (28067).
Lateral side.
Subsurface level, 2893½ ft., Kawkawlin Field, Michigan.

CONTINUED ON PAGE 48

ANNALS OF CARNEGIE MUSEUM, Vol. 36

Art. 4

Plate 2

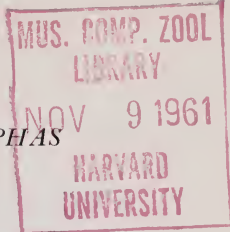


- Fig. 21, 21a. *Eunicites consimilis* sp. nov.
Maxilla V, right jaw (28068).
Lateral view.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 22. *Eunicites catastomus* sp. nov.
Maxilla I or V, left jaw (28070).
Under side.
Subsurface level, 2913 ft., Kawkawlin Field, Michigan.
- Fig. 23. *Eunicites catastomus* sp. nov.
Maxilla I or V, left jaw (28069).
Under side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 24-26. *Leodicites confragosus* sp. nov.
Maxilla II, right jaw (28071).
Lateral, upper, and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 27-29. *Leodicites crassimarginatus* sp. nov.
Maxilla II, left jaw (28072).
Under, lateral, and upper sides.
Subsurface level, 2898½ ft., Kawkawlin Field, Michigan.
- Fig. 30-32. *Ungulites? chilalloeus* sp. nov.
Maxilla I, right jaw (28073).
Under and lateral sides.
Subsurface level, 2913 ft., Kawkawlin Field, Michigan.
- Fig. 33. *Anisocerasites cultidaclylus* sp. nov.
Maxilla III or IV, left jaw (28074).
Upper side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 34, 35. *Anisocerasites convexus* sp. nov.
Maxilla III or IV, right jaw (28075).
Lateral and upper sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 36, 37, 36a, 37a. *Anisocerasites caudagallus* sp. nov.
Maxilla III or IV, right jaw (28076).
Upper and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 38, 39. *Anisocerasites conjunctus* sp. nov.
Maxilla III or IV, left jaw (28077).
Lateral and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 40. *Marleneites constrictus* sp. nov.
Maxilla II or III, right jaw (28079).
Upper side.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 41, 42. *Diopatraites connexus* sp. nov.
Mandible (28080).
Upper and under sides.
Subsurface level, 2931½ ft., Kawkawlin Field, Michigan.
- Fig. 43, 44. *Diopatraites corrugatus* sp. nov.
Mandible (28083).
Upper and under sides.
Subsurface level, 2937½ ft., Kawkawlin Field, Michigan.
- Fig. 45. *Diopatraites cultellus* sp. nov.
Mandible (28082).
Upper side.
Subsurface level, 2913 ft., Kawkawlin Field, Michigan.

ART. 5. NOTES ON THE GENUS *THERMONIPHAS*
(LEPIDOPTERA: LYCAENIDAE)*

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The excellent revision by M. Henri Stempffer (1956, p. 38) has placed this once badly misunderstood genus on solid footing. Not long ago I undertook a thorough examination of the material in the Carnegie Museum collection in order to identify and arrange it in accordance with his findings. The outcome of this work, in addition to the desired curatorial improvements, was a certain amount of new information which I present here.

Thermoniphas Karsch 1895

Two groups of species may be recognized within this genus, one of them further divisible into two subgroups, but the sharpness of these divisions is blurred by the existence of several intermediate or annectant species. For whatever they may be worth, these groups are characterized as follows:

1. *plurilimbata* group. Females largely white above, without discoidal (cell-end) mark, with fuscous borders and little or no discal or basal blue, the postmedian series of marks absent or very faint. Males diversely patterned above, generally easily identifiable to species on pattern alone.

A. *plurilimbata* subgroup. Males fuscous and white above. Male genitalia with valva long and slender, constricted at or before its middle, with a small distal acuminate process from its ventral edge. Includes: *plurilimbata* Karsch; *stempfferi* sp. nov.; *fumosa* Stempffer.

B. *albocaerulea* subgroup. Males largely bright blue above, with hind wing costal area extensively pure white. Male genitalia without acuminate process on valva, which is proportionately less slender, barely or not at all constricted in middle. Includes: *albocaerulea* Stempffer; *leucocyanea* sp. nov.

2. *micylus* group. Females with pale areas above more or less heavily invaded by blue and occasionally by fuscous as well; postmedian series of marks present, usually heavy; females above with discoidal mark present (occasionally faint). Males uniformly dusky violet blue above with vague, rather narrow fuscous borders, virtually unidentifiable without recourse to the male genitalia, which are varied in form, but different from the configurations of group 1 above. Includes: *micylus* Cramer; *distincta* Talbot; *togara* Plötz; *alberici* Dufrane; *fontainei* Stempffer; *kigezi* Stempffer.

The "difficult" species are three: 1. *fumosa* Stempffer which, though placed above in group 1A, is the only member with the discoidal mark below and traces of postmedian spots on the fore wing above in the female. 2. Especially, *caerulea* Stempffer, which can not be assigned to either of the above groups. It has male genitalia absolutely conformable with those of subgroup 1A, and as in group 1 it lacks the postmedian spots on the fore wing of the female above; yet it has in the female a well developed discoidal mark on both surfaces of both wings and the fore wing is shaded basally with bluish; all as in

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group 2. Likewise the male coloration above, though brighter blue, is more like that of group 2 than that of subgroup 1B. 3. Finally, *bibundana* Grünberg is too poorly characterized to place in either group and remains unknown to me as it was to Stempffer.

Pattern key to males

Note: bibundana Grünberg and *distincta* Talbot, are not included.

1. a. Fore wing above with some white in disc; no blue above.....2
 b. No white in disc; fore wing blue/violet with fuscous borders.....4
2. a. Hind wing above largely fuscous; fore wing white does not reach inner margin (though it may reach 2A); discoidal mark usually present on fore wing above *fumosa* Stempffer
 b. Hind wing above extensively white; white of fore wing reaches inner margin broadly; no discoidal mark on fore wing above 3
3. a. Fore wing above, white reaches costa *plurilimbata* Karsch
 b. Fore wing above, white ends at M_2 or M_1 , leaving costa broadly fuscous *stempfferi* sp. nov.
4. a. Hind wing above with costal area broadly pure white, reaching inward to costal edge of cell and to M_1 or M_2 5
 b. Hind wing above blue or fuscous to costa 6
5. a. Fore wing below, postmedian series of marks abruptly absent or very faint below M_3 ; hind wing above with spot on costa at 2/3 very large and dark *leucocyanea* sp. nov.
 b. Fore wing below with postmedian series of marks continuous to 2A; coastal spot on hind wing above fainter..... *albocaerulea* Stempffer
6. a. Upper side dark blue, without marked violet tinge; hind wing marginal markings lost in general infuscation of border area *caerulea* Stempffer
 b. Upper side blue, distinctly violet tinged; usually some traces of the marginal complex are visible on the hind wing above, often the complete complex 7
7. a. Hind wing above with the subterminal line and the terminal row of spots separated by a row of sharp white crescents; terminal spot in Cu_1 - Cu_2 almost as deep as wide..... *alberici* Dufrane
 b. Hind wing above with subterminal line faint to absent; the crescents between it and terminal row of spots grayish or bluish, never sharp and clear; terminal spot in Cu_1 - Cu_2 always much wider (vein to vein) than deep (base to termen) 8
8. The following species run here and can not safely be discriminated except by the male genital structures: *micylus* Cramer; *togara* Plötz; *fontainei* Stempffer; *kigezi* Stempffer.

Pattern key to females

Note: bibundana, distincta, stempfferi not included: *togara* included only with considerable doubt.

1. a. Fore wing above without discoidal (cell-end) mark; upper side largely white, with little or no blue basally; fore wing above with postmedian series of marks absent or very faint 2

- b. Fore wing above with a spot, often thin and linear, at cell-end (exceedingly faint in *kigezi*); upper side often heavily infuscated, nearly always with some blue or green; postmedian series of marks usually well developed 5
2. a. Hind wing below with the terminal spot in Cu_1 - Cu_2 large and black, with much metallic blue scaling within 3
- b. Hind wing below, this spot small, not much larger than the terminal spots costad of it, without included blue scaling or with a few scales only 4
3. a. Fore wing below with postmedian series of marks abruptly faint below M_3 and absent in Cu_2 -2A..... *leucocyanea* sp. nov.
- b. This line well developed to 2A..... *albocaerulea* Stempffer
4. a. Fore wing above with faint traces of postmedian series of marks in Cu_1 - Cu_2 -2A; hind wing above with a large spot between Sc and Rs near costa *fumosa* Stempffer
- b. Fore wing above without any trace of postmedian series; hind wing above without large costal spot (though the one on under side shows through by transparency) *plurilimbata* Karsch
5. a. Fore wing above without postmedian spot row..... *caerulea* Stempffer
- b. This series present, at least partially..... 6
6. a. Fore wing above, spot at cell-end short and thick, not reaching as far as base of M_3 7
- b. This spot thin, linear, reaching entirely across cell-end to base of M_3 8
7. a. Fore wing above, the postmedian spot in Cu_2 -2A is absent or much fainter than those costad..... *kigezi* Stempffer
- b. This spot present, as heavy as those costad..... *fontainei* Stempffer
8. a. Fore wing above in certain lights rather brilliantly greenish iridescent in the blue areas (when, rarely, this is absent, both wings are fuscous and white with no bluish at all); hind wing above the marginal complex has very prominent white lunules between terminal spots and subterminal line *alberici* Dufrane
- b. Fore wing above never with any such brilliant iridescence, the blue shading always present but dull; the white lunules in marginal complex usually dull, grayish 9
9. a. Hind wing above with area beyond cell-end whitened; hind wing above with costa whitened; lunules in marginal complex bright *togara* Plötz?
- b. Fore wing above with area beyond cell-end washed with blue or infused with fuscous, never whitened; hind wing above with costal area fuscous without whitening; lunules in marginal complex dull *micylus* Cramer

Key to males, genital structures

Note: *bibundana* Grünberg not included.

1. a. Valva ending bluntly, without long acuminate process 2
- b. Valva ending in a long acuminate process, or with such a process arising from it near the end..... 4

2. a. One of the largest setae on the valva arising from valva well before its end, not much thicker than the next largest seta 3
 b. All setae from very near the distal end of valva, the largest two or three times as thick as the next largest *fontainei* Stempffer
3. a. Valva with sides subparallel, apex rounded; five large setae in terminal group *albocaerulea* Stempffer
 b. Valva with sides distinctly divergent distally, apex truncate; seven setae in terminal group *leucocyanea* sp. nov.
4. a. Acuminate process of valva nearly as long as valva itself, which is short and broad; the process arising terminally; vinculum with a large lobate expansion on either side; penis distinctly sinuate *alberici* Dufrane
 b. Acuminate process much shorter than the valva which is usually rather long and slender; the process usually arises from ventral border before end; vinculum usually but little expanded; penis not sinuate 5
5. a. Acuminate process of valva rising from a much expanded base barely beyond middle of valva, then abruptly angled distad *micylus* Cramer
 b. Acuminate process arising directly from valva well beyond middle, not strongly angled 6
6. a. One of the terminal setae clearly larger and longer than the others .. 8
 b. No single seta of the terminal group clearly larger and longer than the others 7
7. a. Four setae in terminal group, subequal, one arising at base of acuminate process; anellus arms diverging almost immediately from a very short stalk *caerulea* Stempffer
 b. Of the setae in terminal group, two are clearly longer than the others and arise subterminally; three others are shorter but in size grade into other still shorter setae; none arises at base of acuminate process; anellus arms diverging from end of a distinct stalk which is as slender as basal parts of arms *stempfferi* sp. nov.
8. a. Two setae in terminal group in addition to the dominant one; valva proportionately broad (about half as broad as long) *togara* Plötz
 b. Three or more setae in addition to dominant one 9
9. a. Dominant seta arising basad of origin of acuminate process *kigezi* Stempffer
 b. Dominant seta arises distad of origin of this process 10
10. a. Dominant seta arises well basad of end of valva; four long setae in addition to it *distincta* Talbot
 b. Dominant seta arises terminally or very nearly; three long setae in addition to it 11
11. a. Acuminate process not, or barely, surpassing tip of valva; no seta from its base *fumosa* Stempffer
 b. Acuminate process distinctly surpassing tip of valva; a seta arising at its base *plurilimbata* Karsch

Thermoniphas plurilimbata Karsch 1895

A female from Luluabourg, Kaisai, Congo (*leg.* Seydel) in the museum collection probably represents the nominate subspecies, while a male from

Medje, Oriental, Congo (reported by Holland 1920, p. 234) is referable to ssp. *rutshurensis* Joicey & Talbot, though the fuscous vein-streaking of the hind wing is poorly developed. A possibly more consistent difference between the two subspecies may be the thickness of the terminal spots on the hind wing above and below. These spots are large and round in the Luluabourg female, small and flattened—almost bar-like—in the Medje male as well as in Joicey & Talbot's figure (1921, plate 16, figure 96).

Thermoniphas stempfferi sp. nov. (Plate 1, Fig. 4, 7).

Male. Upper side. Fore wing white with a broad (ca. 1.5 mm.), rather sharp fuscous border the whole length of the costa, including base of cell and base of inner margin; apex and termen also broadly (ca. 2 mm.) edged with fuscous. Hind wing white, fuscous in extreme base; the basal small black spot in interspace between Sc and cell shows through faintly by transparency; farther distad, between Sc and Rs, is a large quadrate black spot as wide as the interspace and about half as thick; terminal area broadly (ca. 2 mm.) fuscous with terminal spots large and round, ringed narrowly but sharply with white. Tail at Cu_2 longer than distance between ends of veins Cu_1 and Cu_2 . Under side. Both wings white, without discoidal (cell-end) streak on either vein. Fore wing with marginal complex (terminal line, terminal spots, subterminal line) as usual save that subterminal line is proportionately heavier and the whole complex is lost apically in a brown shade; postmedian series parallel to termen though the segments below M_3 are disjunct and diagonal; this series much displaced distad, lying closer to marginal complex than the complex is thick and lost apically in the brown shade, of which it forms the approximate basal edge. Hind wing with marginal complex typical, terminal spots in $Rs-M_1$ and Cu_1-Cu_2 larger than the others, the latter black instead of brown, with a few metallic scales within. Postmedian series as on fore wing displaced distally, lying closer to the marginal complex than the complex is thick, parallel to termen in general contour, but irregular in detail costad of M_3 and the segments disjunct below M_3 . About two-thirds out in costal area a large quadrate black spot in interspace Sc-Rs as wide as the interspace and nearly as thick. At about 1/4 from base another smaller spot in the same interspace. No spot in cell and none in basal part along inner margin.

Male genitalia (Fig. 1). Dorsal structures conforming to the general type in the genus; vinculum with an abrupt rounded expansion on either side just above the valvae. Valva proportionally a little thicker than in the other members of the *plurilimbata* subgroup with acuminate process long, the part beyond distal end of valva about one-third as long as the whole valva; distal end of valva with two long setae arising subterminally and three, much shorter, arising terminally, grading in size into the normal valval setae. Anellus Y-shaped, with a rather long slender stalk, about half as long as width of valva at its narrowest point, the arms diverging first at an acute angle, then, because of a bend in each arm, obtusely, their distal ends broad, lamellar, the edges more or less diffuse.

Length of fore wing: 12.5 mm.

Holotype, male, Batanga, Cameroun, from the Holland collection, no further data; male genitalia slide no. C-717. C. M. Ent. type series no. 392.

Remarks. A most distinctive species, coming perhaps closest to *plurilimbata*

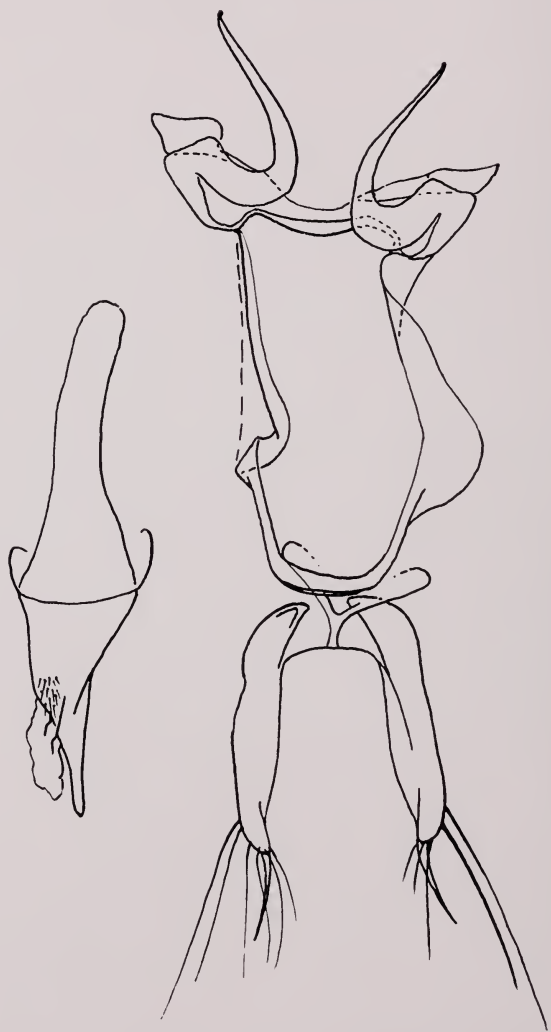


Fig. 1. *Thermoniphys stempfferi* sp. nov., male genitalia (holotype); penis on left

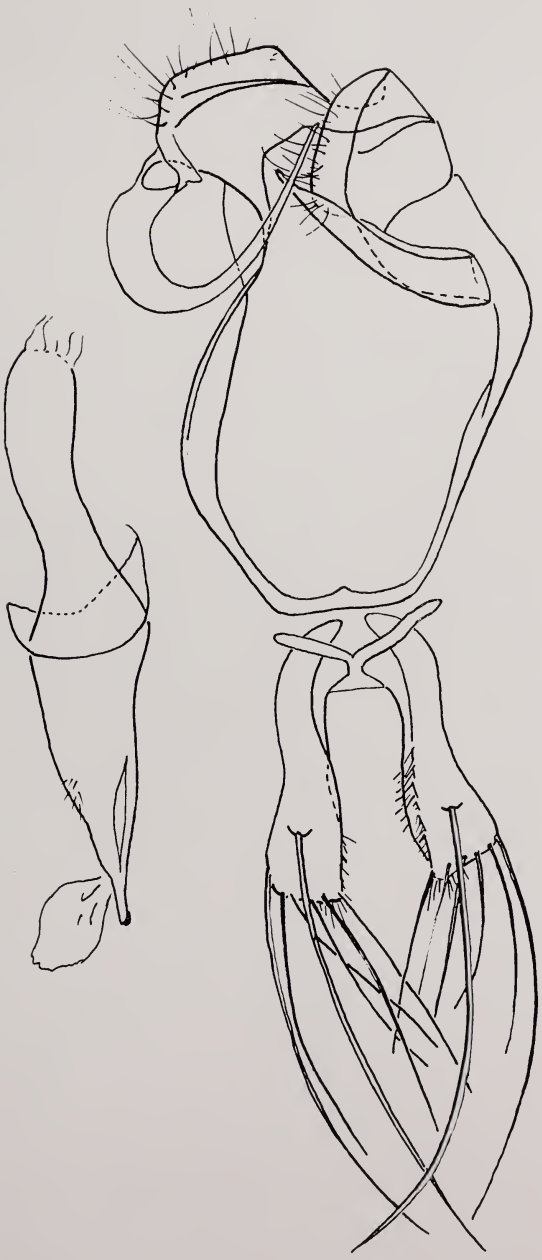


Fig. 2. *Thermoniphas leucocyanea* sp. nov., male genitalia (holotype); penis on left

Karsch in appearance, but immediately distinguishable from it by the broadly fuscous fore wing costa, the hind wing with fuscous in base, prominent black spot on costa and more solidly infusate border. On the under side the brown apical shade of the fore wing and absence of the basal spots in cell and along inner margin of the hind wing are unique in the genus, while the postmedian line is found displaced so far distad only in *leucocyanea* sp. nov., though an intermediate condition occurs in most of the other members of the *plurilimbata* group, including *caerulea*.

It is a pleasure to dedicate this distinctive species to M. Henri Stempffer, in partial recognition of his years of careful, accurate work on African Lycaenidae.

Thermoniphas fumosa Stempffer 1952 (Plate 1, Fig. 1, 3).

Specimens are at hand from the following localities, considerably extending its known range (Nigeria, N. Cameroun, Congo).

Cameroun: Batanga; Efulen; Lolodorf (including 2 females); Efulup, 90 miles E. of Metet; Ekuf, 35 miles E. of Lolodorf.

Gabon: Talaguga, Ogové R.

There is a certain amount of variation among these specimens, chiefly in the extent of the white patches on the fore wing and the degree of development of the fore wing discoidal mark above (almost absent, for example, in both males from Batanga which, further, also have the fore wing termen more rounded and the markings below fainter. Plate 1, Fig. 2). Stempffer (1952, p. 119) does not mention the faint traces of the postmedian series visible in the females on the fore wing above posterior to M_3 , which show quite distinctly in our two specimens (cf. Plate 1, Fig. 3).

Thermoniphas leucocyanea sp. nov. (Plate 1, Fig. 5, 6, 8, 9).

Male. Upper side of both wings bright blue, barely tinged with violet. Fore wing with a fuscous border, basally diffuse and extending basad briefly on the veins, thicker at apex. Costa with a trace of purer, paler blue. Hind wing with costal area inward to cell and M_1 pure white save for a distal patch of blue in $Rs-M_1$, and a small amount of white also in basal half of M_1-M_2 ; two-thirds out along costa a large black patch in $Sc-Rs$. Margin narrowly fuscous with faint traces of marginal spots. Under side markings faintly visible by transparency. Tail at Cu_2 about as long as distance between ends of veins Cu_1 and Cu_2 . Under side of both wings pure white, the discoidal mark on fore wing absent, on hind wing indicated only very faintly. Fore wing with marginal complex about typical save that the subterminal line is less crenulate. Postmedian series displaced considerably distad (closer to marginal complex), but present only costad of M_3 . Hind wing with the usual small basal and large distal black spots in $Sc-Rs$, the latter as wide as the interspace; a small black spot in cell but none along basal part of inner margin. Marginal complex typical, the terminal spots rather large and round, those in $Rs-M_1$ and Cu_1-Cu_2 considerably larger than the others, the latter black with a distal curved line of metallic blue within. Postmedian series complete, of thin brown bars as usual, and, as in fore wing, displaced far distad.

Female. Upper side of both wings pure white without discoidal marks. Fore wing with base and basal part of costa bluish gray, becoming thin to-

wards middle of costa where a broad fuscous apical-terminal border begins, of the same general shape and thickness as in *plurilimbata* and females of *fumosa*, its inner edge prominently dentate, the points on the veins. Hind wing with a prominent large black spot between Sc and Rs two-thirds out along costa; marginal complex large, the terminal spots round, that in Cu_1-Cu_2 especially so; the postmedian series distinct, very close to marginal complex and both are fused and indistinct in a marginal fuscous shade in $Rs-M_1$, from the postmedian series to the termen; base of wing lightly dusted with black. Under side as in the male with these exceptions: the fore wing postmedian series present faintly in $M_3-Cu_1-Cu_2$; the large black marginal spot in Cu_1-Cu_2 larger and more heavily marked with blue; along inner margin, about one-third out from base, a small black spot present.

Male genitalia (Fig. 2). Dorsal structures as typical of the genus. Valva sinuous, regularly widening distad, the end truncate, diagonal to axis of valva; no acuminate process; one large seta arising at about three-fourths of valva and a distal series of six slightly smaller setae. Anellus Y-shaped, on a short stalk, the arms straight, long, forming an angle of about 120° .

Length of fore wing: male, 15.0 mm.; female, 15.5 mm.

Holotype, male, Lolodorf, Cameroun, Apr. 6, 1920 (A. I. Good); C. M. Acc. 6552, male genitalia slide C-719. *Allotype*, female, same locality and collector, Oct. 31, 1913, C. M. Acc. 5263. C. M. Ent. type series no. 393.

Remarks. Very closely allied to *albocaerulea* Stempffer, differing in the following particulars: heavier apical black spot on hind wing above in both sexes; more distally displaced postmedian series on both wings below (visible on the hind wing above in the female as well); the abrupt disappearance (male) or faintness (female) of this series below M_3 on fore wing below, and its much reduced thickness on the hind wing; absence of the discoidal mark in both sexes on the fore wing below and in the female on the hind wing as well. The male genitalia have the anellus arms longer and diverging at a much greater angle; the valva differs in its distal regular increase in width and in having six distal setae (in addition to the dominant one) instead of four.

There is a second female in the collection, from Talaguga, Ogové R., Gabon, which differs in several ways from the allotype. On the hind wing above there is almost no white between the subterminal line and the postmedian series, the whole being fuscous with the white lunules in the marginal complex concomitantly thinner as well. Below, the postmedian series on the fore wing is continued to 2A, though very faintly, the apical two or three bars are much thicker and the whole series lies still closer to the subterminal line, fusing with it apically. On the hind wing this series is also farther distad, the bars somewhat heavier, apically fusing with the subterminal line. Without further material it is impossible to say what significance, if any, should be attached to these differences.

Thermoniphas micylus Cramer 1780

In the typical subspecies (Plate 1, Fig. 11, 14) the blue of the males is dark, the border heavy. Females are likewise dark, more infuscated, showing a virtually entirely fuscous hind wing and on the fore wing the blue dull, dark,

without white, appearing to overlay a fuscous ground. Beneath, the postmedian series of the fore wing is very disjunct and strongly curved apically. Stempffer records the nominate subspecies from Liberia and Togo; also, Nigeria and Cameroun, but see below for discussion of material from the latter two regions. Specimens are at hand from:

Liberia: Harbel, Ganta, Yendamalahoun, Bomi Hills, Zorzor (all *leg.* R. M. Fox; in all, a long series of both sexes).

Ghana: Accra (short series of males only).

Thermoniphas micylus colorata Ungemach 1932

Stempffer (1956, p. 41) notes that females of typical *micylus* from southern Nigeria and Camerouns are paler and more extensively bluish than in specimens from farther west. Our material bears this out completely (cf. Plate 1, Fig. 12, 15). In addition, our few specimens, especially from Cameroun (where it seems to be rare and local, in contrast to its abundance in Upper Guinea), show the postmedian series below to be much less irregular and the males with a distinctly less infusate border. In these traits these specimens agree with Stempffer's remarks (p. 42) on *colorata*. Females, further, agree rather well with Ungemach's colored figure (1932, p. 97, plate 2, figure 14) of *colorata*, which he described from Ethiopia and which Stempffer records as well from Tanganyika. In spite of the fact that I have seen no material from these eastern areas, and that there is currently a large hiatus between them and the Nigerian and Camerouns records, I am nonetheless inclined to place the latter with *colorata*. Certainly they are close, and they appear to be closer to it than to nominate *micylus*. Specimens in the museum collection are from:

S. Nigeria: Old Calabar (3 males, 1 female); Bonny (1 male).

Cameroun: Lolodorf (1 male, 1 female); Ngobilo (1 male, 1 female).

The presence, in the Nigeria-Cameroun region, of a form more closely allied to relatives in Ethiopia and Tanganyika than to those in the Liberia-Ghana region, finds interesting parallels in other butterflies. The eastern riodinid, *Abisara neavei* Riley, has a subspecies, *latifasciata* Riley, in the mountains that lie along the Nigeria-Cameroun border, while in these same mountains fly (subspecifically undifferentiated) the nymphalid *Issoria excelsior* Butler (otherwise known only from the Ruwenzori) and the lycaenids *Uranothauma antinorii* Oberthur and *U. nubifer* Trimen, both of which are otherwise confined to eastern Africa from Rhodesia or Natal north to Ethiopia. *Spindasis banyoana* Bethune-Baker (1926, p. 398) was described from these same mountains and later (Carpenter 1935, p. 392, 415) recorded from Ethiopia, Uganda, and Kavirondo.

That the pluvial periods of the Pleistocene created conditions permitting the eastward movement of certain West African elements is well known. The foregoing suggests that they may also have permitted the westward movement of certain eastern African elements, although apparently on a more modest scale and probably over a different route (cooler, drier). The close systematic relationship of these western relics to their eastern counterparts—they are either undifferentiated or at most slight subspecies—implies that their separation from the parent stock took place in the relatively recent past, in all probability in the last glacial (pluvial) stage.

Thermoniphas togara Plötz 1880 (*sensu* Stempffer 1956)

This species appears to be rare in Cameroun, whence we have only two males from Mekas and a female (identity uncertain) from Metet.

Thermoniphas alberici Dufrane 1945

By far the commonest species of the genus in Cameroun and Gabon. Among the long series in the museum collection are several pairs taken *in copula*, making it possible to associate the sexes with a high degree of confidence. The females of these pairs agree with one another and with a large number of additional females associated with males (genitally determined) both by numbers and by localities. Unfortunately these are not at all the same as the female (from N'Long, Cameroun) selected as "neallotype" by Stempffer (1956, p. 46). This latter, indeed, appears to be *kigezi* Stempffer (See below), leaving the true female of *alberici* still to be described:

Female (Plate 1, Fig. 10, 13). Upper side white. Fore wing with a narrow discoidal (cell-end) bar completely crossing the cell; apex with a large quadrate fuscous patch, its inner edge approximately delimited by the postmedian series of spots which is thick (segment in M_3 -Cu, usually at least as thick as wide) and well developed to 2A; also from the apical patch runs a thick fuscous border with a white bar-like inclusion in each interspace between M_2 or M_3 and 2A. Veins narrowly fuscous between this border and postmedian series and a little basad of the latter as well. Base of wing almost as far as cell-end shaded with fuscous, overlaid with a brilliant greenish blue iridescence only visible in certain lights. This iridescence lies below M_2 and midline of cell and extends from near base to the postmedian series. Hind wing with a thin bar at cell-end; postmedian series well developed, as thick as, or a little thicker than, its fore wing counterpart; marginal series well developed, the terminal spots nearly round, clearly and sharply ringed with white. Costa inward to cell and Rs fuscous, with under side markings visible by transparency. Under side as in male, the markings perhaps a little heavier.

This is the only species in the genus whose female shows this brilliant iridescence on the fore wing, which rarely may be only feebly developed.

There are two females from Efulen, Cameroun, in the collection which I somewhat hesitantly assign here. They differ from the above description in lacking any trace of this iridescence. They also lack the duller bluish basal shading of females of the other members of the *micylus* group, giving them a very distinctive fuscous-and-white look.

Specimens of *alberici* in the museum collection are from these localities (*=genitally determined):

*Fernando Po.

Cameroun: *Lolodorf (including one pair *in cop.*); *Batanga; Efulen; Elat; Bipindi; Ubenji; Asandik (83 miles SE. of Efulen).

Gabon: *Kangwe, Ogové R. (including three pairs *in cop.*).

French Congo: Evuni [not located].

Thermoniphas fontainei Stempffer 1956

To the localities (all in the Congo) recorded by Stempffer may be added the following, represented in the Carnegie Museum collection (*=genitally determined):

Cameroun: Elat (1 female); Tibati (1 female).

Gabon: *Kangwe, Ogové R. (series).

Not located: *Igenja (A. C. Good); *Wambaka (A. C. Good).

Thermoniphas kigezi Stempffer 1956

Thermoniphas alberici Dufrane ♀: Stempffer 1956. p. 45, plate 3, figures 7, 8.

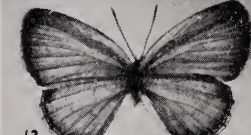
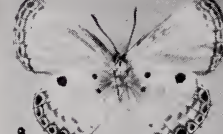
From Lam, Cameroun (A. I. Good, Jan. 16, 1920) there are only two specimens of *Thermoniphas* in the museum collection, one a male, the other a female. The male has been determined genitally to be *kigezi* Stempffer, previously known only from the type locality of Kayonga, Kigezi, Uganda. The female is distinctive in being extensively whitish above, with Cu₂-2A segment of the postmedian series on the fore wing virtually absent, in sharp contrast to the well developed remainder of the series. These same traits are present also in a single female from Metet, Cameroun. Both these specimens agree well with Stempffer's figures of female *kigezi* save that the discoidal mark of the fore wing above is well developed though short and not reaching the base of M₃. Stempffer's figure and description of the "neallotype" of *T. alberici*, also from Cameroun, agrees with these Cameroun females of *kigezi* and accordingly differs from the true female of *alberici*, as discussed above.

It is possible that a racial difference exists in the distinctness of the fore wing discoidal mark above in the female; nearly absent in Uganda, rather heavy in Cameroun.

EXPLANATION OF PLATE 1

- Fig. 1. *Thermoniphas fumosa* Stempffer, ♂. Talaguga (near Kangwe) Ogové R., Gabon.
- Fig. 2. *Thermoniphas fumosa* Stempffer, ♂. form?—Batanga, Cameroun.
- Fig. 3. *Thermoniphas fumosa* Stempffer, ♀. Lolodorf, Cameroun.
- Fig. 4. *Thermoniphas stempfferi* sp. nov. holotype ♂.
- Fig. 5. *Thermoniphas leucocyanea* sp. nov. holotype ♂.
- Fig. 6. *Thermoniphas leucocyanea* sp. nov. allotype ♀.
- Fig. 7. Under side of specimen shown in Fig. 4.
- Fig. 8. Under side of specimen shown in Fig. 5.
- Fig. 9. Under side of specimen shown in Fig. 6.
- Fig. 10. *Thermoniphas alberici* Dufrane, ♀. Benito, Spanish Guinea.
- Fig. 11. *Thermoniphas micylus micylus* Cramer, ♂. Harbel, Liberia.
- Fig. 12. *Thermoniphas micylus colorata* Ungemach, ♂. Ngobilo, Cameroun.
- Fig. 13. Under side of specimen shown in Fig. 10.
- Fig. 14. *Thermoniphas micylus micylus* Cramer, ♀. Harbel, Liberia.
- Fig. 15. *Thermoniphas micylus colorata* Ungemach, ♀. Ngobilo, Cameroun.

Plate 1. (Photographs by R. M. Fox)



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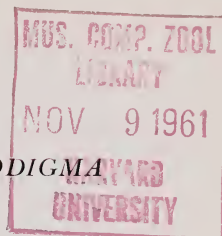
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ART. 6. A REVIEW OF THE AFRICAN GENUS *DAPIDODIGMA*
(LEPIDOPTERA: LYCAENIDAE)*

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Associate Curator of Insects and Spiders

This curious genus has long been considered to be monotypic, represented only by the species *hymen* F., occurring from Sierra Leone to the Congo River. Until recently the only specimens in Carnegie Museum were several from southern Cameroun, mostly taken by A. I. Good many years ago. They had been identified as *hymen* and since their agreement with published descriptions and figures was good there was no reason to question the identification. The receipt of a fine series of the genus from Liberia, however, altered this state of affairs considerably, for they were unquestionably different from the Cameroun series. At about this same time we received additional specimens of the genus from the Katanga which appeared to represent yet another entity. The survey here given is based on this assembled material.

Dapidodigma Karsch

Dapidodigma Karsch 1895, Entomologische Nachrichten, v. 21, p. 310 (Genotype, by original designation, "*Papilio liger* Cramer . . . 1782 . . . = *Papilio hymen* F. . . 1775").

Amblypodia, *Hesperia*, *Myrina*, *Papilio*, *Polyommatus*, *Sithon*: auct., partim.

Key to species and subspecies

1. a. Male with hind wing scent patch wholly below M_1 and costal cell vein; under side of fore wing without specialized creamy scaling on inner margin; female with the white radiating streak (extending from inner margin near base diagonally across wing to apex) interrupted in Sc-Rs subterminally by a transverse brown bar *hymen* F.
- b. Male with hind wing scent patch extending well costad of cell and M_1 ; underside of fore wing with a large specialized patch of creamy scales on middle of inner margin, reaching costad to Cu_2 (*demeter* sp. nov.) ... 2
2. a. Under side of hind wing (both sexes) with the central white line in the three diagonal segments (M_3 - Cu_1 - Cu_2 -2A) of the postmedian band thicker than the black-brown which flanks it on either side; fore wing postmedian band with its outer white line in M_1 - M_2 straight and transverse but sending a slender inter-nervural white streak distad *demeter nuptus* ssp. nov.
- b. Under side of hind wing (both sexes) with the central white line in the three diagonal segments of the postmedian band thin, thread-like, much thinner than the flanking black; fore wing postmedian band with the outer white line in M_1 - M_2 V-shaped, the apex pointing distad *demeter demeter* sp. nov.

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Dapidodigma hymen Fabricius, 1775 (Plate 1, Fig. 1, 4, 7, 10).

Papilio hymen Fabricius 1775, Systema Entomologiae, p. 519 (Sierra Leone).

Papilio liger Cramer 1782, Papillons Exotiques, v. 3, p. 109, plate 254, figures E, F ("Suriname . . . also . . . Sierra Leona").

Sithon hymen: Kirby 1871, A Synonymic catalogue of diurnal lepidoptera, p. 413 (synonymizes *liger* to *hymen*).

This species is most readily distinguished in the male by the posterior displacement of the creamy androconial patch on the hind wing above. Costally it does not extend at all beyond M_1 and the costal edge of the cell, while posteriorly it reaches beyond the cell border and distally it extends to well beyond the middle of the distance between cell-end and termen in the medio-cubital region. Even more striking is the complete absence of the patch of creamy-colored specialized scales on the inner marginal area of the fore wing below, the normal pattern elements continuing fully developed to lost vein 1A, posterior to which they are more or less lost in the narrow marginal whitish. On the under surface the only other trait that is apparent is the great reduction in intensity of the whitish streak that runs from near the base of the inner margin diagonally outward towards the apex. Though noticeable in both sexes this is especially marked in females (See key). It should be added however, that, despite this, females of *hymen* and *demeter* are exceedingly similar and may not always be separable on pattern characters.

Length of fore wing. Male, 17-18.5 mm., mean (4 males), 17.5 mm.; female, 18-18.5 mm., mean (2 females), 18.2 mm.

Material examined. All from Liberia (Harbel; Wanau Forest Reserve (near Ganta); Ganta) leg. R. M. Fox.

Remarks. See under *demeter*.

Dapidodigma demeter sp. nov. (Plate 1, Fig. 2, 5, 8, 11).

Male. Differs from that sex of *hymen* chiefly as follows: somewhat larger (see measurements below); the cream-colored androconial patch of the hind wing above extends well costad of the cell and M_1 , reaching as far as Sc; posteriorly it does not extend farther than the cell-end and base of M_3 , and distally it reaches to barely a third of the distance between cell-end and termen. Thus the whole patch in *demeter* appears to have migrated costad, as compared with *hymen*. On the hind wing termen the costal dark patch is narrower (ca. 1 mm.) than in *hymen* (ca. 1.5 mm.) and inwardly more vaguely defined. On the fore wing below the inner marginal area from Cu_2 and the posterior border of the cell is almost entirely filled with white (cream-colored in the central half or so, becoming bluish peripherally); all that here remains of the ground color is a subterminal bar of brown. On the hind wing the white streak is rather well developed, though distally cut by the brown post-median band and a distal contiguous wedge of brown ground color in Sc-Rs.

Female. Almost identical with that sex of *hymen*. On the upper surface of the hind wing the pale blue extends a little farther towards the tornal region, leaving the distal black-brown only as a slender, vague, lunulate band subterminally in Cu_3 - Cu_2 -2A, separating the basal blue from the subterminal bluish lunules there. On the under surface the inner marginal area of the fore wing below Cu_2 is white (as in all females of the genus), with the stronger brown line elements present in reduced form. The white streak of

the hind wing is well developed, and not, or only partly, cut by the postmedian band in Sc-Rs.

Length of fore wing. Male, 19.0-21.0 mm., mean (5 specimens), 20.0 mm.; female, 17.5-20.5 mm., mean (10 specimens), 18.8 mm.

Holotype, male, Efulen, S. W. Cameroun, no date (A. I. Good), from the Holland Collection; *allotype*, female, same locality, Aug. 29, 1912 (H. L. Weber), C. M. Acc. 4794. *Paratypes*: 3 males, 4 females, same data as holotype; 1 male and 4 females, Efulen (H. L. Weber), dated respectively, Feb. 10, 1913; July 6, 1916; Sept. 3, 1920; Jan. 11, 1914; Dec. 9, 1924; 1 female, Asandik, 83 miles SE. of Efulen, May 10, 1913 (H. L. Weber). C. M. Ent. type series no. 394.

Remarks. In addition to the type series there is a male (Plate 1, Fig. 3, 6) from Efulen (Good) which differs in several respects from the types (and accordingly not made one of them). This specimen is smaller (length of fore wing, 17 mm.), the androconial patch of the hind wing above only about half the size, centered on the origin of Rs, does not reach either Sc or the base of M_3 , and is very weakly colored; the apical black-brown patch of this wing is fully twice as thick as in the other specimens, more sharply defined inwardly. On the fore wing below, though the inner marginal area below Cu_2 is all white (save for a small spot just below origin of Cu_2 , absent in the type series males) it is only feebly tinged creamy in the center. Whether this is just an individual variant of *demeter*, or yet another species is not determinable.

The question of the relationship between *demeter* and *hymen* is still open. I have treated them as different species because of the distinct and sharp structural difference (scent patch locus) which is more likely to be a trait of specific distinctness than one of subspecies. Yet the mutual allopatry which the two forms show from the meager material at hand and the absence of difference in the male genitalia make the possibility of their being merely geographic races still one to be considered.

Dapidodigma demeter nuptus ssp. nov. (Plate 1, Fig. 9, 12).

Male. Differs from typical *demeter* in the slightly smaller hind wing androconial patch and much thicker apical black-brown patch (ca. 3 mm.) above; in the more extensive white of the inner marginal area below, blue-white invading well into Cu_1 - Cu_2 ; in the much stronger white streak of the hind wing, not cut by the postmedian line of Sc-Rs; in the whiter terminal area between the black submarginal thread line and the termen; in the paler tornal area below M_3 and distad of the diagonal segments of the postmedian band; in the thicker white central line of these segments, thicker than the black-brown which flanks the white.

Female. The blue of both wings above is more extensive, on the fore wing reaching well into the base of M_3 - Cu_1 , which it barely touches in the typical subspecies, and on the hind wing fusing completely with the subterminal bluish lunules in Cu_1 - Cu_2 -2A. Below, as in the male, the inner marginal white of the fore wing is more extensive, extending (between median and postmedian lines) well into Cu_1 - Cu_2 ; on the hind wing the differences are as given for the male, save that the white streak is here even stronger, stout and continuous from inner margin to apex.

Length of fore wing. Male, ca. 18.5 mm. (single specimen, damaged); female, 19 mm. (2 specimens).

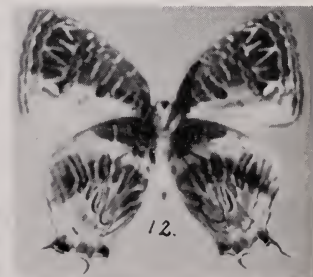
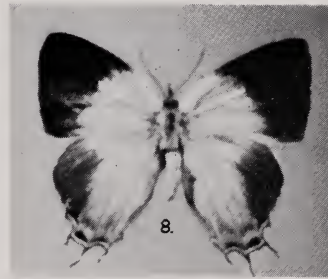
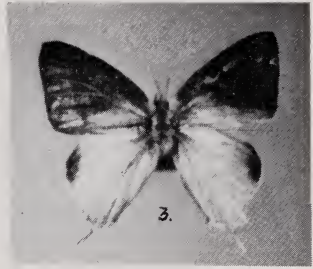
Holotype, male, Kabongo, Katanga, Nov. 18, 1952 (Ch. Seydel), C. M. Acc. 15717; *allotype*, female, same locality and collector, Oct. 27, 1953, C. M. Acc. 16038; one female *paratype*, same locality, collector and accession number, Nov. 16, 1953. C. M. Ent. type series no. 395.

Remarks. This subspecies marks a notable extension of the known range of the genus. M. Seydel writes that it was a recent discovery with him, the holotype being the first specimen he had ever taken in many years of collecting in the Katanga.

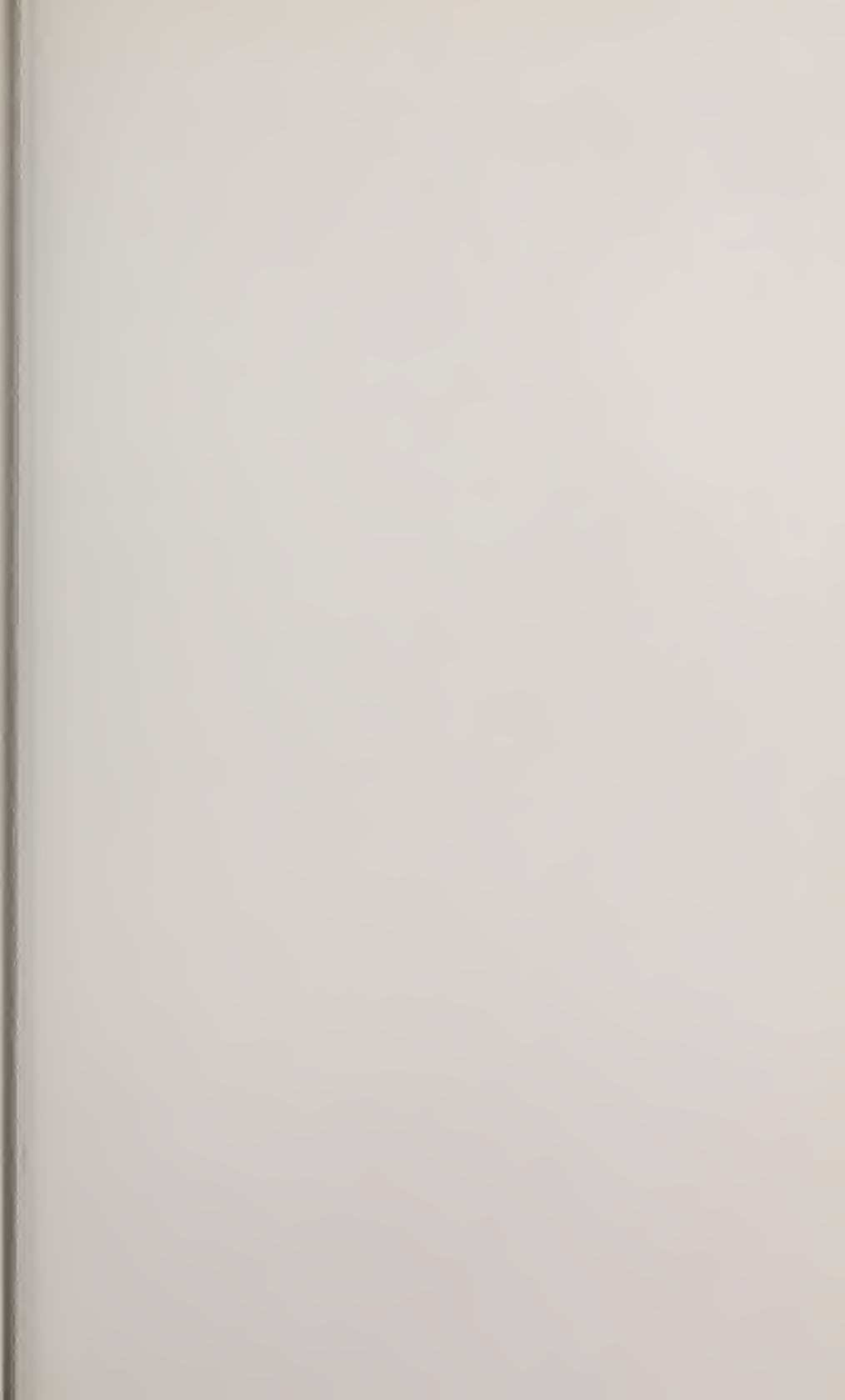
EXPLANATION OF PLATE 1

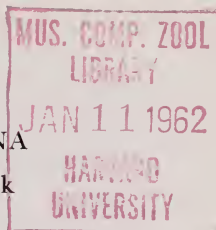
- Fig. 1. *Dapidodigma hymen* F., ♂. Harbel, Liberia.
- Fig. 2. *Dapidodigma demeter* sp. nov., holotype ♂.
- Fig. 3. *Dapidodigma demeter* variety? Efulen, Cameroun.
- Fig. 4. Under side of specimen shown in Fig. 1.
- Fig. 5. Under side of specimen shown in Fig. 2.
- Fig. 6. Under side of specimen shown in Fig. 3.
- Fig. 7. *Dapidodigma hymen* F., ♀. Wanau Forest Reserve, near Ganta, Liberia.
- Fig. 8. *Dapidodigma demeter* sp. nov., allotype ♀.
- Fig. 9. *Dapidodigma demeter nuptus* ssp. nov., paratype ♀.
- Fig. 10. Under side of specimen shown in Fig. 7.
- Fig. 11. Under side of specimen shown in Fig. 8.
- Fig. 12. Under side of specimen shown in Fig. 9.

Plate 1. (Photographs by R. M. Fox)









ART. 7. FOSSIL MAMMALS FROM MONTANA

Pt. 1. Additions to the Late Miocene Flint Creek Local Fauna

By CRAIG C. BLACK

Associate Curator of Vertebrate Fossils, Carnegie Museum

Carnegie Museum field parties first under Earl Douglass and later under J. LeRoy Kay have made extensive collections from the Tertiary formations of southwestern Montana. Douglass reported on many of the early collections and later J. J. Burke (1935, 1936, 1938) described a number of rodents and rabbits obtained by these expeditions. Since Burke's work, however, a great many additional specimens have been added to these collections and much of this material adds appreciably to our knowledge of these faunas. This report is the first in a proposed series dealing with these collections.

The name Flint Creek Beds was originally proposed by Douglass (1903) for a series of beds exposed on the east side of Flint Creek along a bluff extending from just north to several miles south of the town of New Chicago, Granite County, Montana. Earlier (1900) he had described an oreodont from this deposit but did not use the term Flint Creek Beds at that time. In 1903 he listed the following species as having been collected from the Flint Creek Beds:

Ogmophis arenarum
Talpa? platybrachys
Sciurus
Mylagaulus paniensis
Aelurodon? brachygnathus
Protohippus?
Hesperhys vagrans
Merychys smithi
Poatrephes paludicola
Merycochoerus laticeps
Procamelus
Palaeomeryx borealis

Later in the same paper he described many of these forms but did not again mention *Sciurus*, *Protohippus*, *Procamelus*, or *Palaeomeryx borealis*. In 1908, he described *Aphelops montanus* from these beds and in 1909, the *Palaeomeryx borealis* material placing it in a new genus, *Dromomeryx*. Since 1909, the fauna has not been restudied and three of the forms listed by Douglass (1903) as occurring in the fauna were never further described or discussed. Thorpe (1937) and Schultz and Falkenbach (1940 and 1941) re-examined the oreodont material. In the Guidebook for the Eighth Field Conference of the Society of Vertebrate Paleontology edited by R. W. Fields (1958) the following faunal list is given for the Flint Creek local fauna:

Ogmophis arenarum
Talpa platybrachys
Mylagaulus paniensis
Sciurus sp.
Aelurodon? brachygnathus
Parahippus sp.
Hypohippus sp.

Merychippus insignis
Aphelops montanus
Poatrephes paludicola
Ticholeptus smithi
Meryocochoerus
Brachycrus laticeps
Procamelus sp.
Dromomeryx borealis
Merycodus sp.

Parahippus sp., *Hypohippus* sp., *Merychippus insignis*, and *Merycodus* sp. are recorded in this list for the first time and *Hesperhys vagrans* was omitted. Fields (1958, p. 33) states that unpublished lists of specimens from the Carnegie Museum collections were supplied by Dr. J. LeRoy Kay and used in the compilation of the faunal lists for the Guidebook. I would assume from this, and from the fact that, to my knowledge, no other work aside from that already mentioned has been published on the Flint Creek local fauna, that these additions listed under the Flint Creek local fauna were based on specimens in the Carnegie Museum collection.

Study of specimens in the Carnegie Museum collections make it necessary to revise this latest faunal list. There is no evidence for the occurrence of *Parahippus* in this fauna. *Hypohippus* and *Merychippus* are both present but the material is too fragmentary for specific identification. The presence of *Merycodus* is verified by C.M. 3345, a fragmentary right maxilla with M¹ and half of P⁴. With the material described below, the species known to date from the Flint Creek local fauna are:

Ogmophis arenarum
Talpa? *platybrachys*
Hypolagus sp.
Mylagaulus paniensis
Citellus (*Otospermophilus*) *primitivus*
Monosaulax sp.
Cotinus alicae gen. et sp. nov.
Aelurodon brachygnathus
Hypohippus sp.
Merychippus sp.
Aphelops montanus
Hesperhys vagrans
Poatrephes paludicola
Ticholeptus zygomaticus smithi
Brachycrus laticeps
Procamelus sp.
Dromomeryx borealis
Merycodus sp.

The illustrations are by Mr. Clifford Morrow and were made possible by a grant from the Gulf Oil Corporation. All measurements are in millimeters. The following abbreviations are used:

C.M. Carnegie Museum
a-p anteroposterior
tr. transverse

Order Lagomorpha
Family Leporidae
Hypolagus sp.

Material. C.M. 3593, an isolated right upper molariform tooth and C.M. 13941, LP₃.

Description. These two specimens are of interest as they represent the first record for the Order Lagomorpha in this fauna. They are certainly assignable to *Hypolagus* but beyond that little can be said about their affinities. The hypostria of the upper molariform tooth is deep and markedly crenulate. The anteroexternal fold of P₃ is shallow while the posteroexternal fold is deep. The external face of P₃ is covered with cement.

Order Rodentia
Family Mylagaulidae
Mesogaulus paniensis (Matthew)
Figure 1

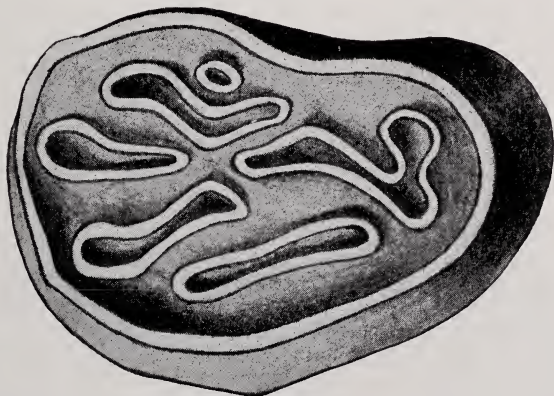


Fig. 1. *Mesogaulus paniensis*, C.M. 9564, RP⁺ anterior end to right. $\times 10$

Material. C.M. 844, a partial right mandible with P₄ and M₂; C.M. 9564, RP⁺; and C.M. 13594, RP⁺.

Description. Douglass (1903, p. 172) referred a partial right mandible, C.M. 844 with P₄ and M₂ to *Mesogaulus paniensis*. At that time, he stated "There is one and only one prismatic molar, which was evidently persistent, as it is nearly or quite as high as the premolar. There is in this specimen no trace of a molar posterior to it." Though M₃ has been lost, or possibly shed, in this specimen, it was at one time certainly present. There is a large interdental wear surface on the posterior side of M₂ which clearly demonstrates that M₃ was present for at least part of the animal's life. Whether the tooth was shed during life or lost after death is unknown.

In addition to the partial mandible there are two upper premolars which have not previously been described for this species. Both teeth are well worn, one considerably more so than the other. There are five main fossettes with their long axes oriented anteroposteriorly. The anterior fossette is the longest with the four shorter ones grouped around it posteriorly. The anterior fossette at one stage of wear has a short arm directed buccally at right angles to the long axis of the tooth. With further wear this arm is separated from the main fossette as a small circular lake. There is a second small circular lake near the buccal margin of the tooth which is lost with wear. The entire outer surface of C.M. 13594 is covered by a thin layer of cement but there is no trace of cement on C.M. 9564. Deposition of cement appears to begin rather

late in the individual's life at least for species of *Mesogaulus*. In *M. novellus* cement occurs only near the base of the premolar crowns and only on well worn teeth, and no cement is present on the unworn premolars of *M. proximus* or *M. pristinus*.

Mesogaulus paniensis is larger than *M. ballensis* and *M. novellus* but there is little to distinguish it from *M. proximus* and *M. pristinus* from the Lower Madison Valley formation. A review of the species of *Mesogaulus* will be published at a later date and it is possible that these three species will be found to be synonymous.

Measurements

		a-p	tr.
C.M. 844	P ₄	6.80	4.00
C.M. 844	M ₂	3.00	3.20
C.M. 9564	P ⁴	7.20	5.20
C.M. 13594	P ⁴	7.20	4.80

Family Sciuridae

Citellus (Otospermophilus) primitivus Bryant

Material. C.M. 727, a badly crushed and damaged skull and jaws.

Description. A detailed description and comparison of this material with *Citellus (O.) primitivus* from the Lower Madison Valley formation is in progress in connection with a review of North American Tertiary squirrels. The material from Flint Creek resembles that of the type where comparable and there is little doubt but that it represents the same species.

Family Castoridae

Monosaulax sp.

Figure 2



Fig. 2. *Monosaulax* sp. C.M. 8722, RP₄-M₂, anterior end to right. $\times 10$

Material. C.M. 8722, a partial right mandible with P₄-M₂.

Description. The teeth are only moderately worn with the mesofossettid closed on M₁ and M₂ but still open on P₄. The hypostrids on P₄-M₂ are long and very deep. There are three primary fossettids on M₁ and M₂ and on M₂ there are also two small fossettids, one on either side of the anterior fossettid. These would both be quickly obliterated with further wear.

Discussion. The teeth of this specimen are considerably larger and higher crowned than *Monosaulax* sp. cf. *M. hesperus* from the Deep River local fauna (Black, 1961). Whatever the specific assignment of these two specimens may ultimately prove to be, the Flint Creek species is certainly more advanced than that from Deep River.

Measurements

	a-p	tr.
P ₄	5.20	4.40
M ₁	3.50	4.20
M ₂	3.60	4.30

Family Cricetidae

Tribe Eumyini

*Cotimus** gen. nov.

Type. *Cotimus alicae*† sp. nov.

Diagnosis. Mandible slender, more delicate than in *Eumys*, *Scottimus*, or *Leidymys*; three crests passing from anterior cingulum to protoconid and metaconid, on M₁; posterior protoconid arm passes to base of entoconid on M₂; reaches lingual border on M₃; molars decrease in length from M₁ to M₃.

Cotimus alicae sp. nov.

Figure 3

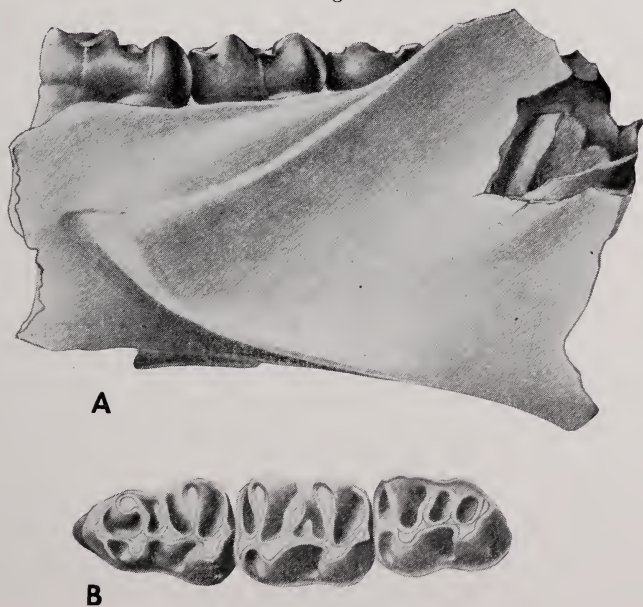


Fig. 3. *Cotimus alicae* gen. et. sp. nov. Type, C.M. 8868
A. Lateral view of left mandible. $\times 10$. B. LM₁-M₂, anterior end to left. $\times 15$

Type. C.M. 8868, partial left ramus with M₁-M₃.

Diagnosis. As for the genus.

Description. The mandible is slender and shallow. The dorsal masseteric crest terminates anteriorly in a prominent shelf below the center of M₁.

*From *cos*, *cotis* Latin, flintstone and *mus* Latin, mouse.

†Named for Alice Guilday who collected the specimen.

Inferiorly the masseteric fossa is set off by a strong, raised border, while there is a shallow furrow above the dorsal masseteric crest.

All of the cheek teeth are low crowned. They decrease in length from M_1 to M_3 . The anteroconid on M_1 is large and strongly connected to the metaconid. Buccally there is a crest from the anteroconid to the protoconid. The anterior protoconid arm passes from the protoconid directly forward to join the anteroconid. These three crests, in conjunction with the strong posterior protoconid arm passing to the metaconid, isolate two rather deep pits in the anterior portion of the tooth. Behind the posterior protoconid arm a strong mesolophid passes to the lingual border of the tooth where it is joined by a crest passing along the lingual border from the metaconid. The mesoconid is large on M_1 , much more so than on M_2 or M_3 . A short anterior hypoconid arm passes to the entoconid. There is a small hypoconulid and strong posterior cingulum which meets the entoconid at its posterolingual corner. The buccal valley between the protoconid and entoconid is broad. On M_2 the anterior cingulum is well developed both internally and externally. The protoconid and metaconid are joined through the anterior protoconid arm. The posterior protoconid arm passes across the tooth to the base of the entoconid, failing to reach the lingual margin. A short mesolophid is present between the posterior protoconid arm and the anterior hypoconid arm. The latter passes almost directly across the tooth to the entoconid. The hypoconulid and posterior cingulum on M_2 resemble those on M_1 . The buccal valley is constructed, curving posteriorly, and there is a small styloid at the base of the protoconid. M_3 , although reduced in size, is similar in most respects to M_2 . However, the posterior protoconid arm reaches the lingual border and the hypoconid-hypoconulid are expanded.

Measurements

	a-p	tr.
M_1	2.00	1.15 - 1.45
M_2	1.80	1.60 - 1.65
M_3	1.70	1.40 - 1.20

Discussion. There is little resemblance between *Cotimus* and Tertiary members of the cricetid Tribe Hesperomyini. *Michomys* (Hoffmeister, 1959, p. 697) from the Sante Fe formation appears to be a true hesperomyine and is probably closely related to *Peromyscus*. *Cotimus* differs from these forms in showing no alteration of major cusps, strong protoconid arms, and a complexly crested anterior half of M_1 .

The affinities of this genus are with the eumyine cricetids which were so abundant during the Oligocene but are rare elements in Miocene faunas. *Copemys* (Wood, 1936) from the Sante Fe, while probably an eumyine, differs strikingly from *Cotimus*. The isolated metaconid on M_1 , partial alternation of major cusps, and peculiar position of the posterior cingulum on M_2 are all quite in contrast to the condition of *Cotimus*.

Cotimus is much closer to the Oligocene *Eumys* than to any other genus known to date and it seems to be closer to the plains *Eumys* complex than to the intermontaine species of that genus. White (1954, p. 410) has pointed out that the intermontaine species of *Eumys* tends to be larger, more robust, and with higher crowned teeth than their contemporaries on the plains. However, *Cotimus*, although an intermontaine form, is much more reminiscent of the plains species as regards its slender, delicate mandible and small, low-crowned teeth.

M_1 of *Cotimus alicae* shows some resemblance to that of *Cricetodon nebraskensis* (Wood, 1937, p. 256) especially in the development of the mesolophid. The second molar, however, bears little resemblance to that of *Cricetodon nebraskensis*. Galbreath (1953, p. 69) in discussing the *Eumys* complex from the Oligocene of Northeastern Colorado pointed out that *Cricetodon nebraskensis* Wood falls within the normal variation of the *Eumys obliquidens* population from the Cedar Creek member of the White River formation and hence is quite possibly conspecific with *E. obliquidens*. In many respects *Cotimus alicae* and *Eumys obliquidens* appear to be rather closely allied. In both species the posterior protoconid arms turn postero-mesial on M_2 and M_3 either uniting with the entoconids or passing to the lingual margin. In both species the mesolophid on M_1 is longer than the posterior protoconid arm. However, Galbreath states (1953, p. 67-71) that in all samples of *Eumys* from the later Oligocene deposits of Northeastern Colorado there appears to be a trend towards the loss of the mesolophid on M_1 , the displacement of the posterior protoconid arm anteriorly to unite with the metaconid on M_2 - M_3 , and a reduction of the lingual portion of the anterior cingulum. These changes are all trending away from the condition seen in *Cotimus alicae*.

It would appear, therefore, that the most likely ancestral condition for *Cotimus* is that seen in the early mid-Oligocene populations of *E. obliquidens*. The changes that took place between the middle Oligocene and late Miocene were a strengthening of the mesolophid on M_1 , a continued emphasis on the postero-mesial development of the posterior protoconid arm on M_2 and M_3 with a consequent reduction in the importance of the mesolophid, a trend towards complication of the crests passing to the anterior cingulum, and a decrease in overall size and robustness of the mandible.

AGE OF THE FAUNA

Wood, et al. (1941) placed the age of the Flint Creek local fauna as early Barstovian, probably equivalent to the Deep River local fauna. The rodents from Flint Creek are, however, somewhat more advanced than those known from Deep River and agree much more closely with those from the Lower Madison Valley formation. *Mesogaulus paniensis* has higher crowned teeth and is larger than *M. ballensis* of the Deep River but it can scarcely be separated from *M. proximus* and *M. pristinus* of the Lower Madison Valley. *Citellus (Otospermophilus) primitivus* occurs in both the Flint Creek and Lower Madison Valley faunas but is unknown from the Deep River. The beaver is advanced over that from the Deep River being both larger and having higher crowned teeth. From this it appears obvious that the Flint Creek local fauna and the Deep River local fauna are not of equivalent age but that the Flint Creek local fauna is younger, probably middle to late Barstovian in age and quite probably equivalent to part of the Lower Madison Valley fauna.

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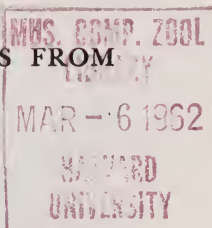
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ART. 8. NOTES ON PLEISTOCENE VERTEBRATES FROM
WYTHE COUNTY, VIRGINIA

BY JOHN E. GUILDAY

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Carnegie Museum



In or about the year 1868 Edward D. Cope collected samples of Pleistocene cave breccia from three localities on the eastern side of the Shenandoah Valley in Wythe County, Virginia. "... two of them near together, on the property of Abraham Painter, and the third about three miles on the same side of the same ridge. The Kanawha (New) River cuts the hill at the latter point, and on the side of a bluff the cavity occurred . . ." (E. D. Cope, 1869a, p. 171). Upon application to the county surveyor, O. P. Hay learned that the Painter Farm was along the New River near the town of Ivanhoe. (O. P. Hay, 1923, p. 353). According to Dr. Jean Lowry, former district geologist, Commonwealth of Virginia, (letter) the Painter Farm now belongs to a Mr. Early, and Cope's fossil sites are known as Early's Cave, or Early's Pits.

Cope identified 21 species of mammals, one bird *sp.*, *Crotalus*, *Tropidonotus* (= *Thamnophis*?), *Trionyx*, *Cistudo* (= *Terrapene*), *Menopoma* (= *Cryptobranchus*), fragment of a pelecypod and 7 species of land snails. The specimens were present as inclusions in the dark brown breccia. Angular fragments of quartzite and wild cherry seeds ("*Celtis pumila*", Cope, 1869a, p. 173) also occurred as inclusions. The bones and teeth were poorly preserved and unmineralized.

O. P. Hay, (1923, p. 351) is of the opinion that the age is "... somewhere about the middle of the Pleistocene." Certainly the presence of *Megalonix*, *Equus*, and *Tapirus* place the fauna in the Pleistocene, probably in an interglacial. Unfortunately there are, as Cope states, three different localities involved so that the collection can not be viewed as a single fauna. Each locality may have represented a different time interval. Hay's opinion of the age of this collection is about as exact as the situation warrants. There is no collaborative geological evidence.

I wish to thank the authorities at the American Museum of Natural History, especially Dr. Malcolm C. McKenna, for permission to study the collection, and Dr. Craig C. Black, Associate Curator of Vertebrate Fossils, and Miss Caroline A. Heppenstall, Assistant Curator of Mammals at Carnegie Museum for their assistance.

Cope described two new genera and five new species of Pleistocene mammals from this collection, all of them invalid. The collection itself is incomplete at the present time. Various specimens were apparently lost. Indeed, Cope himself lost one of them prior to publication. Twelve of the 21 mammals originally described are still in the collection, including the types of *Stereodectes tortus* Cope (= *Marmota monax* Gmelin), *Tamias laevidens* Cope [= *Tamias striatus* (Linnaeus)], and *Sciurus panolius* Cope [= *Glaucomys volans* (Linnaeus)].

In the list below some of the italicization follows Cope.

Annotated list of the collection as it exists today, with a revision of the taxonomic standing of some of the forms:

Class: Mammalia

Order: Insectivora

Family: Soricidae

Blarina cf. *brevicauda* (Say)

Blarina sp. Cope, 1869a, p. 175

Material: 1 mandible with complete dentition ". . . about the size . . . of *B. talpoides*." Specimen lost.

Order: Chiroptera

Family: Vespertilionidae, sp. ?

Vespertilio, sp. Cope, 1869a, p. 176

Material: "numerous bones". Specimens lost.

Order: Edentata

Family: Megalonychidae

Megalonyx cf. *jeffersonii* Harlan

Megalonyx jeffersonii Harlan. Cope, 1869a, p. 172

Material: "fragments of teeth". Specimens lost.

Order: Lagomorpha

Family: Leporidae, gen. et sp.?

Lepus sylvaticus, *Bach.* Cope, 1869a, p. 175

Sylvilagus floridanus. O. P. Hay, 1923, p. 353

Material: A.M.N.H. 8072. Two fragmentary right mandibles and right p⁴-m¹.

Remarks: These fragmentary jaws and teeth agree with modern *Sylvilagus floridanus*. But the material is not diagnostic. Mandibles of *Sylvilagus transitionalis* and those of the small, late Pleistocene form of *Lepus americanus* (See Guilday and Bender, 1960) also agree quite well with the Wythe County fragments. The coranoid process of the mandible is the most reliable single character for separating isolated lower jaws of cottontail rabbits (*Sylvilagus*) and snowshoe hares (*Lepus*). Unfortunately they are not present in the collection. Both genera occurred in the late Pleistocene, Natural Chimney's local fauna, Augusta County, Virginia.

Order: Rodentia

Family: Sciuridae

Marmota cf. *monax* Gmelin

Stereodectes tortus, *Cope, gen. et sp. nov.*, 1869a, p. 172, plate 3, fig. 3 and 3a

Arctomys monax, *Gmel.* Cope, 1869a, p. 173

Marmota monax. O. P. Hay, 1902, p. 871

Material: A.M.N.H. 8082. A partial upper incisor, the type specimen of *Stereodectes tortus* Cope. The specimen that Cope identified as woodchuck, "One nearly perfect ramus mandibuli" is no longer with the collection.

Remarks: *Stereodectes tortus* was described as a new genus and species from an abnormal woodchuck incisor. It is characterized by a lateral twist, reminiscent of a ram's horn, a condition found in rodents that have met with dental

damage and developed an overgrown incisor. Though not common, this condition is by no means rare, and most large mammal collections contain a few examples. Colyer (1936) lists this condition in primates (*Daubentonia*), lagomorphs, rodents, artiodactyls (*Sus*, *Hippopotamus*) and the hyrax. The degree of torsion of A.M.N.H. 8082 was duplicated in the overgrown incisor of an abnormal woodchuck, C.M. mammal no. 6029.

Tamias cf. *striatus* (Linnaeus)

Tamias laevidens, Cope, *sp. nov.*, 1869a, p. 174, plate 3, fig. 4

Eutamias. T. S. Palmer, 1904, p. 865

Tamias laevidens Cope. O. P. Hay, 1923, p. 353

Material: A.M.N.H. 8081. One partial left mandible with p_4 , broken incisor.

Remarks: The type and only specimen is still partially imbedded in breccia, but all of its salient characters can be seen. The jaw appears to have been broken prior to deposition at about the level of the third molar, and only its anterior half is preserved. An unerupted fourth premolar is in place and partially exposed. The molars are missing. The species *T. laevidens* was based upon the following characters—all invalid.

1. "The first molar [fourth lower premolar] has two anterior cusps instead of one." Cope, 1869a, p. 174. The presence of two anterior cusps, protoconid and metaconid, is a character shared by all sciurids, and can not be used to separate members of the genus *Tamias*.

2. "They [the protoconid and metaconid or p_4] are separated by a deep groove." Cope, *ibid.* So they are in all chipmunks.

3. "There is a little cusp between the external two [—cusps, metaconid and hypoconid.]." Cope, *ibid.* This is again typical for the genus.

I can only imagine that Cope used old animals with advanced toothwear for comparative material, otherwise his remarks on the morphology of p_4 are inexplicable.

4. "The incisor teeth are not striate grooved on their anterior face, as in *T. striatus*, . . ." Cope, *ibid.* This varies individually. Cope's specimen is weakly grooved exactly as in my comparative material of *T. striatus*. The incisors of chipmunks of the genus *Eutamias* are strongly striated, and it is possible that Cope had this in mind.

5. "The ramus is more slender [than *T. striatus*]." Cope, *ibid.* The mandible is slender, an impression heightened by its immaturity and broken ventral border, but no more so than in modern *T. striatus*.

Glaucomys cf. *volans* (Linnaeus)

Sciurus panolius Cope, *sp. nov.*, 1869a, p. 174, plate 3, fig. 5

Material: A.M.N.H. 8576. Fragmentary right mandible containing the stump of an incisor and a partial p_4 .

Remarks: Cope mentions two molar teeth in the specimen, and his figure shows p_4 and m_1 in position in the jaw. The specimen has been damaged subsequently. The first molar has been sheared off at the roots and the lingual half of the fourth premolar is missing. Only the protoconid and hypoconid of p_4 is preserved, together with a trace of the anterior re-entrant between the protoconid and the metaconid. Cope's description of the missing molar, plus the morphology of the remaining tooth and the mandible itself are diagnostic of *Glaucomys*. The masseteric fossa is relatively deep, and the ventral curve of the incisor, as it passes the dorso-lingual root of the angular process is quite prominent, but both variations occur in modern *Glaucomys*. Size is as in modern *Glaucomys volans*.

Family: Castoridae

Castor canadensis Kuhl

Castor fiber, Linnaeus }
C. Canadensis Kuhl } Cope, 1869a, p. 173

Material: "Portion of mandible with three molars."

Specimen lost.

Family: Cricetidae

Neotoma cf. *floridana* (Ord)

Neotoma? *floridanum*, Say and Ord. Cope, 1869a, p. 173

Neotoma floridana ? O. P. Hay, 1923, p. 353

Material: A.M.N.H. 8078. Partial left mandible containing m_1 , m_2 , and incisor.

Remarks: The mandible is from a young individual, undoubtedly a nestling. The mandible was not fully formed and the bone had a porous surface texture. Wear was just beginning on the molars and the occlusal pattern was not yet established. The specimen was compared with a nestling *N. f. magister* from southwestern Pennsylvania, and with the figure of *Parahodomys spelaeus* (in Gidley & Gazin, 1938, p. 61, fig. 33). The animal was obviously a *Neotoma*, but the specimen is too immature and fragmentary for more than a provisional specific identification. Cope mentions an upper molar, incisors, "and other portions," but they are not with the collection now.

Peromyscus, sp. ?

Hesperomys ? *leucopus*, Rafinesque. Cope, 1869a, p. 173

Peromyscus leucopus. O. P. Hay, 1923, p. 353.

Material: "Molar teeth". Specimens lost.

Remarks: Identification of members of this genus to species by the examination of isolated molars is difficult, if not impossible, in many instances. Cope states merely that the teeth were "indistinguishable from those of this common mouse." [*P. leucopus*], Cope, 1869a, p. 173. At the time

Cope made that identification the genus was inadequately known and it is not possible, in the absence of the material, to interpret Cope's remarks in the light of present-day knowledge.

Microtus cf. *pennsylvanicus* (Ord)

Arvicola, sp. Cope, 1869a, p. 173

Arvicola riparia. Cope, 1871, p. 87

Microtus pennsylvanicus. O. P. Hay, 1923, p. 353

Material: A.M.N.H. 8077. Fragmentary left mandible with complete dentition.

Remarks: The teeth are inclosed in flowstone but their occlusal surfaces are well exposed. The specimen appears to be a typical *M. pennsylvanicus*. The identification will have to remain provisional, however, because of the difficulty of separating isolated mandibles of *M. pennsylvanicus* and *M. chrotorrhinus*. Both species are known from the late Pleistocene Natural Chimney local fauna in Augusta County, Virginia (Guilday and Bender, *ibid.*). *M. chrotorrhinus* is of boreal affinities and has a relict distribution in the Appalachian Mountains at the present time. Its presence in a Pleistocene deposit at the latitude of southern Virginia and at an elevation of about 1600 feet would be indicative of boreal conditions. The remainder of the fauna seems to be more indicative of a temperate, interglacial episode. But, because there are three localities involved here, direct association of any two species (with the exception of *Equus* and *Ursus*) is questionable, and the collection can not be looked upon as a contemporaneous "fauna".

Order: Carnivora

Family: Ursidae

Ursus (*Euarctos*), species?

Ursus amplidens, Leidy. Cope, 1869a, p. 176

Material: A.M.N.H. 8033. Unworn crown of right lower m_3 .

Remarks: Cope identified the specimen as *U. amplidens* with no comment other than the fact that it was "identical with that described by Leidy" [Leidy, 1853]. *U. amplidens*, based on a fragment of a mandible with m_3 and an isolated m_1 found near Natchez, Mississippi, has been referred both to the grizzly *U. ferox*, and to the modern black bear *U. americanus*. (See Erdbrink, 1953). Cope's specimen is larger in all dimensions and more rectangular than 27 m_3 's of *U. americanus* from a 17th century archaeological site in eastern Pennsylvania (Pennsylvania State Museum, site no. 36 Ia 12). The usual shape of m_3 , viewed from above, was oval or egg-shaped, but one specimen was found with the rectangular shape of the Wythe County molar. It (G-657) measured, length 16 mm., width 11 mm. The fossil molar, A.M.N.H. 8083 measured,

length 19 mm., width 14 mm. Erdbrink, 1953, p. 309, gives the following observed range for length and width of m_3 in *U. americanus*: length 13-20 mm., width, 10-14 mm. This range is broad enough to include the Wythe County molar as well as some modern grizzly bears. Since students can not agree on the affinities of *U. amplidens*, and since m_3 is so variable in modern bears of the subgenera *Ursus* and *Euarctos*, the Wythe County specimen can not be identified beyond genus. It resembles Leidy's figure of *U. amplidens* no more than it does the modern black bear. It is a bear, probably a euarctoid, but somewhat larger than the present Appalachian form, (based on comparative material from Pennsylvania) and larger than the Pleistocene *U. vitabilis* from Cumberland Cave, Maryland (Gidley & Gazin, 1938, p. 23). *U. vitabilis*=*U. americanus* according to Erdbrink, 1953, p. 311. Imbedded in the same mass of breccia as A.M.N.H. 8083 is an unerupted lower cheek tooth of *Equus* cf. *complicatus*. This is the only instance in the collection in which two species are in direct association. The association with the horse argues for some antiquity for the bear, and this plus the rectangular shape of the tooth make me hesitate to refer it to a large individual of *U. americanus*. Compared with the m_3 of a modern *U. horribilus* from British Columbia (R. W. Watters, no. 27, Carnegie Museum mammal collection) the Wythe County molar is slightly smaller and does not have the triangular crown view.

Family: Procyonidae

Procyon cf. *lotor* (Linnaeus)

Procyon lotor, Linnaeus, Cope, 1869a, p. 176

Material: A.M.N.H. 8079. Right lower m_2 (not m_3 as Cope states).

Family: Mustelidae

Spilogale putorius (Linnaeus)

Galera perdicida, Cope, sp. nov., 1869a, p. 177

Hemiacis perdicida, Cope, 1869b, p. 3

Spilogale putorius, Trouessart, 1897, p. 262

Material: One left mandible with dentition. Figured in Cope, 1869a, plate 3, fig. 2. Specimen lost.

Order: ? Carnivora incertae sedis:

Mixophagus spelaeus Cope. nomen dubium

Mixophagus spelaeus, Cope, 1869a, p. 176, plate 3, fig. 2. (*gen. et sp. nov.*)

? *Procyon*, p., Cope, Trouessart, 1898, p. 252

Myxophagus spelaeus, O. P. Hay, 1923, p. 353

Material: One fragmentary lower molar. Specimen lost.

Remarks: Both the description and the figure of this specimen are inadequate to determine its correct identity. It quite possibly was a broken m_2 of a gray fox, *Urocyon cinereoargenteus*. The type and only specimen is lost. It remains

unidentified, not because of any anatomical peculiarities, but only because of the inadequacy of the material. There appears to have been little ground for the erection of a new genus and species on this single tooth fragment, and it stands as a *nomen dubium*.

Order: Perissodactyla

Family: Equidae

Equus cf. *complicatus*, Leidy

Equus ? *complicatus*, Leidy }
E. americanus, Leidy } Cope, 1869a, p. 176

Equus complicatus ? O. P. Hay, 1923, p. 353

Material: A.M.N.H. 8075. Seven fragments of at least 3 molars. One broken lower cheek tooth, unerupted and without cement, partially imbedded in breccia with bear molar A.M.N.H. 8083.

Remarks: I am merely following Cope's identification. The material is fragmentary, but at least one tooth has been removed from the collection since Cope's time. Since he mentions "Upper and lower milk and permanent molars," he may have had sufficient material to work with. As it stands today, however, the specimens are not identifiable beyond genus.

Family: Tapiridae

Tapirus, species ?

Tapirus haysii, Leidy. Cope, 1869a, p. 176, plate 3, fig. 6 and 6a

Material: A.M.N.H. 8076. One right, one left lower molar partially imbedded in separate pieces of breccia.

Remarks: Both teeth are unworn; each measures 22 mm. in total length and both could possibly have come from the same animal. They appear to be m., but I can not be sure. Isolated tapir teeth are sometimes difficult to assign correct dental position. They appear to fall within the size range of *T. terrestris* and *T. veroensis*, and are below the minimum size of *T. copei* from Port Kennedy Cave, Pennsylvania. (See G. G. Simpson, 1945, for comparative measurements.) Cope's statement that the specimens "have a rather greater antero-posterior diameter than those of the existing Central and South American species" is incorrect. They agree quite well. *Tapirus haysii* Leidy, a name based upon an isolated molar from North Carolina (?), is to be avoided according to Simpson (1945, p. 65-66) on the grounds that the type material is inadequate to define the species.

Order: Artiodactyla

Family: Tayassuidae

Mylohyus, species ?

Dicotyles nasutus, Leidy. Cope, 1869a, p. 176

Mylohyus nasutus. O. P. Hay, 1923, p. 353

Material: "several molar and canine teeth." Specimens lost.

Remarks: Cope neither figured nor measured the specimens. There were at least two Pleistocene species of *Mylohyus* (See Lundelius, 1960, p. 30) in eastern North America, and, in the absence of the specimens, a reappraisal of Cope's specific identification is not possible.

Family: Cervidae

Odocoileus virginianus (Zimmerman)

Cariacus virginianus, Gray, }
Cervus, Bodd. } Cope, 1869a, p. 176

Material: A.M.N.H. 8073. Four upper molars, one broken p_2 , one right lower molar, fragment of a left mandible with m_2 in place.

Remarks: At least three animals are represented. The teeth indicate a form slightly smaller than modern Pennsylvania comparative material. Size variation within *O. virginianus* exhibits such extreme clinal variation at the present day that this character can be of little value in determining specific relationships of fossil material.

Family: Bovidae, species ?

Bos ? antiquus, Leidy }
Bison, Leidy. } Cope, 1869a, p. 176
Bison *sp. indet.* O. P. Hay, 1923, p. 353

Material: "Molar teeth." Specimens lost.

Remarks: Cope makes no further reference to the material and its affinity must remain unknown.

Summary: List of species identified from Cope's 1868, Wythe County, Virginia Collection with taxonomic revision. Asterisk indicates specimen lost and not examined by me.

Present paper	O. P. Hay, 1923	E. D. Cope, 1896a
Amphibia		
<i>Cryptobranchus</i> ? *	<i>Cryptobranchus sp. indet.</i>	<i>Menopoma</i>
Reptilia		
<i>Crotalus</i> ? *	<i>Crotalus sp. indet.</i>	<i>Crotalus</i>
<i>Thamnophis</i> ? *	...	<i>Tropidonotus</i>
<i>Trionyx</i> ? *	<i>Amyda sp. indet.</i>	<i>Trionyx</i>
<i>Terrapene</i> ? *	<i>Terrapene sp. indet.</i>	<i>Cistudo</i>
Aves <i>sp.</i> *	...	"bird of prey", p. 178
Mammalia		
<i>Blarina</i> cf. <i>brevicauda</i> *	<i>Blarina sp. indet.</i>	<i>Blarina</i> <i>sp.</i>
<i>Vespertilionidae</i> *	<i>Vespertilio sp. indet.</i>	<i>Vespertilio</i> <i>sp.</i>
<i>Megalonyx</i> cf. <i>jeffersonii</i> *	<i>Megalonyx jeffersonii</i>	<i>Megalonyx jeffersonii</i>
<i>Leporidae</i> , gen. et <i>sp.</i> ?	<i>Sylvilagus floridanus</i>	<i>Lepus sylvaticus</i>
<i>Marmota</i> cf. <i>monax</i>	<i>Marmota monax</i>	<i>Stereodectes tortus</i> , gen. et <i>sp. nov.</i>
		<i>Arctomys monax</i>
<i>Tamias</i> cf. <i>striatus</i>	<i>Tamias laevidens</i>	<i>Tamias laevidens</i> , <i>sp. nov.</i>
<i>Glaucomys</i> cf. <i>volans</i>	<i>Sciurus panolius</i>	<i>Sciurus panolius</i> , <i>sp. nov.</i>
<i>Castor canadensis</i> *	<i>Castor fiber</i>	<i>Castor fiber</i>
		<i>C. canadensis</i>
<i>Neotoma</i> cf. <i>floridana</i>	<i>Neotoma floridana</i> ?	<i>Neotoma</i> ? <i>floridanum</i>

*Present paper**O. P. Hay, 1923**E. D. Cope, 1896a**Peromyscus* sp. ?**Peromyscus leucopus**Hesperomys* ? *leucopus**Microtus* cf. *pennsylvanicus**Microtus pennsylvanicus**Arvicola* sp.*Ursus* (*Euarctos*) sp. ?*Ursus amplitens**Ursus amplitens**Procyon* cf. *lotor**Procyon lotor**Procyon lotor**Spilogale putorius* **Spilogale putorius**Galera perdicida*, sp. nov.*Carnivora* (*nomen dubium*) * *Myxophagus spelaeus**Mixophagus spelaeus*, gen.
et sp. nov.*Equus* cf. *complicatus**Equus complicatus* ?*Equus* ? *complicatus**Tapirus* sp. ?*Tapirus haysii**Tapirus haysii**Mylohyus* sp. ? **Mylohyus nasutus**Dicotyles nasutus**Odocoileus virginianus**Odocoileus virginianus**Cariacus virginianus**Bovidae*, sp. ? **Bison* sp. indet.*Bos* ? *antiquus**Bison*

One other locality in Wythe County, Virginia, has produced Pleistocene bone since Cope's collection was made. A partial skull and a fragmentary humerus of a peccary, *Platygonus* sp. were recovered from Gardner's Cave, on the L. Y. Gardner Farm, 3½ miles southwest of Wytheville, Virginia. They were donated to the Carnegie Museum (C.M. 6421) by Dr. Lowry. The skull, heavily encased in a yellow, silty breccia, is that of an immature animal. The third upper deciduous molars are just beginning to show signs of occlusal wear. The permanent first molars are in the process of erupting. Measurements appear to fall within the ranges of *P. vetus* and *P. cumberlandensis* as outlined by Gidley, 1921. There is no trace of the intermediary cusps or lophs that, according to Gidley, separates *P. cumberlandensis* from *P. vetus*. The specimen agrees with the published figure of *P. vetus* and, perhaps, should be referred to that species. Simpson (1949) is of the opinion that perhaps all Pleistocene *Platygonus* belong to the single, highly variable species, *P. compressus* LeConte. I prefer to leave the specimen identified only to genus at the present time, and wish merely to call it to the attention of future students.

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ART. 9. THE PLEISTOCENE LOCAL FAUNA OF THE NATURAL CHIMNEYS, AUGUSTA COUNTY, VIRGINIA

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Introduction

Natural Chimneys, one mile north of the town of Mt. Solon, Augusta County, Virginia, is a well known tourist attraction in the west central part of the Great or Shenandoah Valley. Excavation of several small caves at its base proceeded at irregular intervals from 1949 through 1961 by Theodore B. Ruhoff and Carnegie Museum field parties. This collection comprises the Natural Chimneys local fauna, a late Wisconsin to early Recent sample of mammal, bird, reptile, amphibian, fish, snail and millipede remains.

Acknowledgments

Many people have been associated with this study and I wish to thank those who gave so generously of their time and talents. Mr. and Mrs. Gordon E. Brown, the owners of the site, have been extremely co-operative, assisting the field parties in every possible way. Theodore B. Ruhoff, now with the Smithsonian Institution, made the initial discovery of the bone site and during subsequent trips collected the bulk of the matrix from which the fauna was extracted. J. LeRoy Kay, Curator Emeritus of the Section of Vertebrate Paleontology, Carnegie Museum, made several trips to the site and was in charge of the earlier phases of the Museum's field operation. John A. Leppla, Field Associate, Carnegie Museum, spent many months washing matrix and picking out the hundreds of small jaws and teeth. His meticulous concern and scientific approach to the task is directly responsible for the recovery of most of the micro-fauna reported on herein.

Birds were identified by Alexander Wetmore, United States National Museum. The reptiles and amphibians were identified by Neil D. Richmond, Curator of Herpetology, Carnegie Museum. Walter Auffenberg, University of Florida, served as consultant. We wish to thank him for his identification of coachwhip and diamond-backed rattlesnake vertebrae. Gastropods were identified by Juan J. Parodiz, Curator of Invertebrates, Carnegie Museum, millipedes by Nell B. Causey, University of Arkansas. The red fox was checked by Caroline Heppenstall, Assistant Curator of Mammals, Carnegie Museum and by Charles O. Handley, Jr., Associate Curator of Mammals, United States National Museum.

I wish to thank Allen D. McCrady, Mr. and Mrs. Harold Hamilton, Ralph C. Bossart, W. Galen Barton and John A. Leppla for spot-checking details of deposition and geology at the site.

I am grateful to Neil D. Richmond, Harry B. Clench, J. Kenneth Douthett and Craig C. Black, for reading and criticizing portions of this manuscript.

The map was made by Mr. Bossart. Photographs by Neil D. Richmond (Fig. 1) and W. Galen Barton (Fig. 2 and 3). The drawing by Richard W. Lang (Fig. 4) was made possible by National Science Foundation grant, G-20868.

Special thanks are due my wife, Alice M. Guilday, for her invaluable assistance throughout every phase of the project.

Location

The Natural Chimneys are located one mile north of the town of Mt. Solon, Augusta County, Virginia, about fifteen miles west of Harrisonburg, Virginia. Geographical co-ordinates taken from the Parnassus Quadrangle, Virginia Geological Survey map are Lat. 30° 22' N., Long. 70° 5' W., Alt. 1357 feet above sea level.

The site is on the east bank of the wide flat valley of the North River, a tributary of the Shenandoah River system. At this point the Great Valley is 25 miles wide. Its floor lies at an elevation of 1350-1500 ft. Its western rim, Narrow Back Mountain, rises to 2300 ft., its eastern rim, Blue Mountain, to 2500 ft. at this spot. North River which drains the rugged mountain terrain west of the Great Valley enters it at North River Gap, four miles west of Natural Chimneys. Entering a flat valley fully a mile wide, the river turns abruptly north, flows parallel to Narrow Back Mountain for eight miles, then swings east to cross the floor of the Great Valley. Its fall is about 40 ft. per mile as it emerges from the gap. It is clear, cool and moderately swift.

Natural Chimneys lies at the base of a series of low (100 ft.) hills that lie on the floor of the Great Valley and form the east bank of the North River Valley. They face west across the wide expanse of the valley which continues flat for over a mile, rises 300 ft. in the next two miles, then precipitously some 700 ft. to the summit of Narrow Back Mountain some four miles west of the site.

Geology

The Natural Chimneys appear to be erosion remnants of a former fissure cave system. They (Fig. 1) are a group of chert-capped towers of upper Cambrian Elbrook dolomite. At this point in the valley the strata of the dolomite are horizontal. While the North River was flowing at a higher level than it does today, with a correspondingly higher regional water table, the "chimneys" appeared as a series of fissures and sink-holes open on the hilltop at the level of the highest "chimney." Subsequent deepening and lateral erosion of the North River Valley by stream meandering have exposed the dolomite pillars—the former walls between the open sink-holes. Subsequent erosion of the pillars themselves has reduced these former fissure walls to tall stone chimneys. The fortunate feature of a cap of insoluble chert has protected these pillars from destruction. The small caves at their base, Brown's Cave (Fig. 1, right) and the Cave of the Wooden Steps (Fig. 1, left) are probably remnants of former subterranean connections between sink-holes.

Deposition

The major portion of the bones was removed from the floor of Brown's Cave, although a few, including a mandible of *Microtus xanthognathus*, were found in wall cracks in the Cave of the Wooden Steps. In Brown's Cave (Fig. 2) the bone-bearing sector of the earth fill of the cave floor was concentrated about the mouth of the cave and extended back only a few feet. Secondary bone-bearing sites were scattered irregularly in side passages near the entrance. Some pockets of bone were discovered in cave earth on small ledges above the floor of the cave.

The top two feet of cave floor fill was a light coffee-brown when dry, deep red-brown when wet. It contained fragments of dolomite, speleothems, teeth, bone fragments and modern plant rootlets. It is important to note that all



Fig. 1. Natural Chimneys, Mount Solon, Virginia, looking north. Cave of the Wooden Steps, left. Brown's Cave, right



Fig. 2. Entrance to Brown's Cave, Natural Chimneys, Virginia. Note man standing inside the entrance, on fossiliferous matrix

of the rock fragments appeared to have been derived from the surrounding formation, that none was waterworn and that the deposit was not obviously stratified. The matrix was not water deposited but grew in place by decomposition of the surrounding cave walls and filling from above. Below two feet, the matrix turned redder and became sterile of bones and teeth. The dark color of the bone-bearing matrix is undoubtedly due to a higher organic content, possibly associated with owl roosts and wood-rat nests, neither of which occur there today.

The deposit of bone accumulated in several ways. Most important was the activity of owls. Owls, and other raptorial birds, regurgitate pellets of compacted bones, skulls and fur or feathers of small mammals or birds. Bones, lower jaws and partial skulls processed in this manner remain remarkably well preserved, and deposits containing many thousands of such items accumulate in a relatively few years about the roosts. The remains of at least 878 mammals were recovered from the matrix. Of these, 98 per cent. were rabbit-size or smaller. Approximately one-eighth of the entire fauna was shrews and an additional one-half of the total was small cricetid rodents. Mammals larger than a rabbit were represented only by scraps of bone or isolated teeth. This could not be attributed to post-depositional disturbance or water action as the good condition of many of the hundreds of smaller and more delicate bones proves. The presence of milk teeth or unerupted permanent teeth of wood-rats, porcupine, wolf, raccoon, deer, peccary and woodchuck may have meant that the cave was a former denning site at various times in the past. Large mammal bone fragments were invariably heavily gnawed by rodents, and possibly found their way into the cave as a result of the scavenging activities of a resident wood-rat population. The bones may have filtered down from former openings to surface sink-hole entrances in the present roof of the cave, or the present cave walls may have had a resident owl population. The high percentage of nocturnal flying-squirrels and low percentage of diurnal chipmunks are other good indications of owl activity. An owl roost deposit associated with the Sheep Rock Shelter, an archeological site in Huntingdon County, Pennsylvania (Guilday and Parmalee, ms.) had a similar preponderance of flying-squirrels, while at the New Paris #2 local fauna, Bedford County, Pennsylvania, where the victims simply tumbled into an open sink-hole, the proportion of flying-squirrel to chipmunk was ten to one hundred and nine (Guilday and Bender, 1958).

The bones and teeth, with exception of those of the larger mammals, are well preserved. They are a light ivory color and have not been mineralized. One or two are mottled, almost black, and appear to have been mineralized. The only specimens of this color that could be identified were some mandibles of the least shrew *Cryptotis*, the short-tailed shrew *Blarina*, and the pygmy shrew *Microsorex*. Brunner, 1959, working with similar faunas in Germany, has attempted to assign different ages to variously colored bones in chronologically mixed late Pleistocene deposits. This may not always be valid, however. While excavating the New Paris #4 fauna, Allen D. McCrady noted that black bone was almost invariably associated with air pockets and local discontinuities in the mud and rubble matrix. He attributed the coloration to organic action (bacterial ?) during the initial decomposition of the animal, or possibly to a chemical oxidation process. At this latter site all of the specimens, both ivory-white and black, were known to be of a common age.

Faunal List

Phylum Arthropoda

Class Diplopoda (identifications by Nell B. Causey)

Nannaria sp.

Phylum Mollusca (identifications by Juan J. Parodiz)

Class Archaeogastropoda

Hendersonia occulta

Class Mesogastropoda

*Pomatiopsis lapidaria**Valvata* sp.*Leptoxis* (*Mudalia*) *carinata*

Class Basommatophora

*Lymnaea catascopium**Physa heterostrophia*

Class Stylommatophora

*Triodopsis tridentata juxtidentis**Triodopsis* (*Neohelix*) *albolabris**Retinella electrina**Retinella virginica**Anguispira alternata angulata**Helicodiscus parallelus**Gastrocopta* (*Albinula*) *contracta*

Phylum Chordata

Class Osteichthyes

Cyprinidae, indeterminate, minnows

Catostomidae, indeterminate, suckers

Class Amphibia (identifications by Neil D. Richmond)

Diemictylus cf. *viridescens*, red-spotted newt*Ambystoma* sp., salamander*Desmognathus* sp., salamander*Scaphiopus* cf. *holbrooki*, spade-foot toad*Bufo* sp., toad*Hyla* sp., treefrog*Rana* cf. *catesbiana*, bullfrog*Rana palustris*, pickerel frog*Rana* sp., frog sp.

Class Reptilia (identifications by Neil D. Richmond)

Chelydra serpentina, snapping-turtle*Terrapene carolina*, box-turtle*Sceloporus* cf. *undulatus*, fence lizard*Natrix* sp., water-snake*Storeria* sp., red-bellied ? snake*Thamnophis* cf. *sirtalis*, garter-snake*Haldea* sp., earth snake*Diadophis* sp., ring-neck snake*Carphophis amoenus*, worm-snake*Coluber* cf. *constrictor*, black racer*Masticophis flagellum*, coachwhip snake*Opheodrys* sp., green-snake

Elaphe cf. *guttata*, corn-snake
Elaphe sp., rat-snake
Lampropeltis doliata triangulum, milk-snake
Lampropeltis sp.
Crotalus horridus, timber rattlesnake
Crotalus cf. *adamanteus*, diamond-back rattlesnake

Minimum number
of individuals

Class Aves

(Identification and data from Alexander Wetmore)

<i>Anas discors</i> , blue-winged teal	2
<i>Bucephala albeola</i> , bufflehead	1
<i>Oxyura jamaicensis</i> , ruddy duck	1
<i>Accipiter striatus</i> , sharp-shinned hawk	1
<i>Buteo jamaicensis</i> , red-tailed hawk	1
<i>Buteo lineatus</i> , red-shouldered hawk	1
<i>Buteo platypterus</i> , broad-winged hawk	1
<i>Canachites canadensis</i> , spruce grouse	1, or more
<i>Bonasa umbellus</i> , ruffed grouse	3, or more
<i>Pedioecetes phasianellus</i> , sharp-tailed grouse	4, or more
<i>Colinus virginianus</i> , bob-white	1
<i>Meleagris gallopavo</i> , turkey	2
<i>Grus americana</i> , whooping crane	1
<i>Charadrius vociferus</i> , killdeer	1
<i>Philohela minor</i> , woodcock	1, or 2
<i>Bartramia longicauda</i> , upland plover	1
<i>Catoptrophorus semipalmatus</i> , willet	1
<i>Erolia minutilla</i> , least sandpiper	1
<i>Ectopistes migratorius</i> , passenger-pigeon	21, or more
<i>Megaceryle alcyon</i> , belted kingfisher	1
<i>Colaptes auratus</i> , yellow-shafted flicker	1
<i>Centurus carolinus</i> , red-bellied woodpecker	1
<i>Melanerpes erythrocephalus</i> , red-headed woodpecker	2
<i>Dendrocopos pubescens</i> , downy woodpecker	1
<i>Sayornis phoebe</i> , eastern phoebe	3
<i>Contopus virens</i> , eastern wood pewee	1
<i>Petrochelidon pyrrhonota</i> , cliff swallow	8, or more
<i>Perisoreus canadensis</i> , gray jay	1
<i>Cyanocitta cristata</i> , blue jay	1
<i>Pica pica</i> , magpie	1
<i>Sitta canadensis</i> , red-breasted nuthatch	1
<i>Toxostoma rufum</i> , brown thrasher	1
<i>Turdus migratorius</i> , robin	1
<i>Hylocichla</i> sp., thrush (not identified to species)	1
<i>Agelaius phoeniceus</i> , red-winged blackbird	2
<i>Molothrus ater</i> , brown-headed cowbird	1, or more
<i>Junco</i> sp., junco (not identified to species)	1
<i>Zonotrichia albicollis</i> , white-throated sparrow	1
<i>Passerella iliaca</i> , fox sparrow	1
<i>Melospiza melodia</i> , song sparrow	1

Class Mammalia	Minimum number of individuals
Order Insectivora	
<i>Microsorex hoyi</i> , pygmy shrew	7
<i>Sorex</i> cf. <i>cinereus</i> , masked shrew	45
<i>Sorex fumeus</i> , smoky shrew	10
<i>Sorex arcticus</i> , arctic shrew	6
<i>Sorex palustris</i> , water shrew	4
<i>Cryptotis parva</i> , least shrew	5
<i>Blarina brevicauda</i> , short-tailed shrew	56
<i>Condylura cristata</i> , star-nosed mole	5
<i>Parascalops breweri</i> , hairy-tailed mole	3
<i>Scalopus aquaticus</i> , eastern mole	5
Order Chiroptera	
<i>Myotis keenii</i> , Keen's bat	39
<i>Myotis</i> cf. <i>lucifugus</i> , little brown bat	4
<i>Eptesicus</i> cf. <i>grandis</i> , pleistocene brown bat	2
<i>Eptesicus</i> cf. <i>fuscus</i> , big brown bat	1
<i>Eptesicus</i> sp.	12
<i>Pipistrellus subflavus</i> , pipistrelle bat	5
<i>Lasiurus</i> cf. <i>borealis</i> , red bat	1
Order Rodentia	
<i>Marmota monax</i> , woodchuck	2
<i>Citellus</i> cf. <i>tridecemlineatus</i> , thirteen-lined ground squirrel	2
<i>Tamias striatus</i> , chipmunk	6
<i>Glaucomys volans</i> , southern flying-squirrel	15
<i>Glaucomys sabrinus</i> , northern flying-squirrel	13
<i>Tamiasciurus</i> cf. <i>tenuidens</i> , pleistocene red squirrel	5
<i>Sciurus carolinensis</i> , gray squirrel	1
<i>Neotoma floridana</i> , wood-rat	37
<i>Peromyscus</i> cf. <i>maniculatus</i> , deer-mouse	35
<i>Peromyscus</i> cf. <i>leucopus</i> , white-footed mouse	12
<i>Peromyscus</i> sp. (<i>maniculatus</i> or <i>leucopus</i> ?)	83
<i>Synaptomys cooperi</i> , southern bog lemming	13
<i>Synaptomys borealis</i> , northern bog lemming	3
<i>Phenacomys</i> cf. <i>ungava</i> , spruce vole	10
<i>Clethrionomys gapperi</i> , red-backed vole	47
<i>Microtus xanthognathus</i> , yellow-cheeked vole	15
<i>Microtus chrotorrhinus</i> , rock vole	2
<i>Microtus pennsylvanicus</i> , meadow vole	40
<i>Microtus</i> cf. <i>pennsylvanicus</i> or <i>chrotorrhinus</i>	127
cf. <i>Pitymys pinetorum</i> , pine vole	65
<i>Ondatra zibethicus</i> , muskrat	6
<i>Napaeozapus insignis</i> , woodland jumping-mouse	9
<i>Zapus hudsonicus</i> , meadow jumping-mouse	13
<i>Erethizon dorsatum</i> , porcupine	2
<i>Castor canadensis</i> , beaver	1
<i>Castoroides ohioensis</i> , giant beaver	1

	Minimum number of individuals
Order Lagomorpha	
<i>Lepus americanus</i> , snowshoe hare	3
<i>Sylvilagus</i> sp., cottontail rabbit	1
Leporidae cf. <i>Lepus</i> or <i>Sylvilagus</i>	12
Order Carnivora	
<i>Canis</i> cf. <i>lupus</i> , wolf	1
<i>Vulpes</i> sp., red ? fox	1
<i>Ursus</i> cf. <i>americanus</i> , black bear	1
<i>Lynx</i> ?, indeterminate small cat	1
<i>Procyon lotor</i> , raccoon	1
<i>Martes americana</i> , pine-marten	1
<i>Martes</i> cf. <i>pennanti</i> , fisher	1
<i>Mustela vison</i> , mink	2
<i>Mustela</i> cf. <i>frenata</i> , long-tailed weasel	3
<i>Mustela</i> cf. <i>rixosa</i> , least weasel	1
<i>Mephitis mephitis</i> , striped skunk	1
Order Artiodactyla	
<i>Mylohyus</i> sp., long-nosed peccary	1
<i>Odocoileus virginianus</i> , white-tailed deer	2
Cervidae ?, indeterminate large artiodactyl	1

Discussion of Fauna

The bird bones recovered from Natural Chimneys are at the United States National Museum, Washington, D.C. (U.S.N.M.). The remainder of the collection is in the Section of Vertebrate Fossils, Carnegie Museum, Pittsburgh, Pa. (C.M.)

Invertebrates (See Faunal List)

Remains of one calcified millipede *Nannaria* sp. and 13 species of snails, both terrestrial and aquatic, were recovered. No pelecypod remains were recovered strengthening the assumption that the bone-bearing matrix was of terrestrial origin.

Fish (See Faunal List)

Fish remains were common in the matrix. Without exception, however, they constituted fish of "minnow size," the largest perhaps 12" long, the majority less than half of that. Kingfishers, mink, or other terrestrial fish predators may have been responsible for these remains or occasional high waters may have flooded the site allowing schools of small fish to die in the cave as the water receded. If such was the case, however, the flooding was of a benign and temporary nature that disturbed the deposit very little if at all.

Amphibians (See Faunal List)

Material: C.M. 7605 through 7612.

Reptiles (See Faunal List)

Material: C.M. 7589 through 7604, 7614.

Remarks: The coachwhip, *Masticophis flagellum*, 1 vertebra, C.M. 7596 and the diamond-backed rattlesnake, *Crotalus adamanteus*, 1 vertebra, C.M. 7614, are of southern affinities. Neither species is found in Virginia today but approach its southern border. These two species are the only forms in the Natural Chimneys local fauna whose range does not extend as far north as

the site today. Is this an indication that ranges of ectothermal animals will respond more rapidly to temperature change than will those of endothermal animals? Perhaps the temperature rise associated with the post-Wisconsin "Climatic Optimum" was enough to enable these snakes to range farther north than they do today, while endothermal species remained relatively unaffected? This is pure speculation, however. There is no way of knowing whether these snakes were contemporary with the boreal fauna (which seems extremely doubtful), or whether they preceded or followed it in time.

Birds

By Dr. Alexander Wetmore, United States National Museum

In the list of birds, the spruce grouse and the gray jay are species of boreal range that today live in northern coniferous forests. The sharp-tailed grouse, northern and northwestern in modern distribution, has been found recently in late Pleistocene deposits of New Paris #4 sink-hole in Pennsylvania (Wetmore, 1959), so that its occurrence at Natural Chimneys represents a point to the southward in its ancient range. The magpie is definitely western and northern, here recorded for the first time in eastern United States under conditions of natural distribution. The abundance of remains of the passenger-pigeon, now extinct, is interesting, as is a fragment from the skeleton of the whooping crane, formerly common, but for which there are few records in the eastern United States. The remaining species on the list in modern times range widely to the north, and also are found as residents or as migrants in Virginia, so that there is nothing unusual in their presence in this Natural Chimneys fauna at the end of Wisconsin time.

Mammals

Order: INSECTIVORA

Family: Soricidae

The collection is exceptionally rich in shrews. It contains at least 230 lower jaws and 28 partial skulls representing 136 animals belonging to seven species (See Fig. 3). The high number of shrews can be attributed to owl predation. Identification to species was based entirely upon dental and cranial characters. Fortunately most of the mandibles were in excellent condition and characters of specific value were present. The following two keys present characters which will differentiate the mandibles of the soricids of eastern North America. Those marked with an asterisk are present in the Natural Chimneys local fauna.

Key to the Genera of Eastern North American Soricidae Based on Mandibles

A. Size small (ramus length, 6.5 mm.). Entoconid of molars greatly reduced.

*Microsorex**

B. Size large (ramus length, 7 mm. or more). Entoconid of molars well developed.

1. Talonid of M_3 reduced.

*Cryptotis**

2. Talonid of M_3 not reduced.

a. Articular facets of condyle separated by concave area. Angular process short, stocky. Mandible heavy and massive.

*Blarina**

- b. No concave area between articular facets of condyle. Angular process long and delicate. Mandible light and delicate.

*Sorex**

Key to the Genus *Sorex* in Eastern North America Based on Mandibles

The following key to the mandibles of eastern *Sorex* should be used in conjunction with adequate comparative material. It is intended as a working guide only. All measurements were taken with an ocular micrometer under 10× magnification.

- A. Post-mandibular foramen present and well developed.

*Sorex arcticus**

- B. Post-mandibular foramen absent or weakly-developed (See 2a).

1. Valley separating protoconid and hypoconid of M_1 *deep*, extending to external cingulum. (Also true of *S. arcticus*.) Size large, condyle width over 2 mm.

*Sorex palustris**

2. Valley separating protoconid and hypoconid of M_1 *shallow*, extending almost, but not quite to external cingulum.

- a. Size medium, condyle width 2 mm. Post-mandibular foramen present in 20% of cases (5 out of 25 Pennsylvania specimens), but always small and close to mandibular foramen.

*Sorex fumeus**

(In actual practice, *S. fumeus* can be most readily confused with *S. arcticus*, but the following characters separate the two: depth of the proto-hypoconid valley of M_1 , the post-mandibular foramen; the dentary of *S. arcticus* is heavier and the lower incisor is stouter, yet the first molar is slightly smaller than in *S. fumeus*.)

- b. Size small—condyle width 1.5 mm.

- aa. Dentary delicate and elongated, length over 8 mm.

Sorex dispar

(*S. gaspensis* was not examined, but its affinities appear to lie with *S. dispar*.)

- bb. Dentary short and relatively stocky, length 7.5 mm.

*Sorex cinereus**

Sorex longirostris

Sorex cf. *cinereus* Kerr—Masked Shrew

Material: C.M. 7551, 7552. 72 whole or partial mandibles. 3 left and 2 right partial maxillae.

Distribution: Northern North America south to Pennsylvania, thence south in the Appalachian Mountains to Georgia.

Habitat: Cool, damp terrain with a heavy ground cover in both forested and open situations.

Remarks: *Sorex longirostris* occurs or may be expected to occur at the site today (Bruce, 1937). Apart from a slightly smaller average size, its mandible is indistinguishable from that of *S. cinereus*. Both species may conceivably have been represented in the deposit. The specimens were referred to *S. cinereus* because they averaged slightly



Fig. 3. Lower jaws of shrews from the Natural Chimneys local fauna
Scale in mm.

Top to bottom:	<i>Microsorex hoyi</i>	C.M. 7554a	C.M. 7554b
	<i>Sorex cf. cinereus</i>	C.M. 7551a	C.M. 7552a
	<i>Sorex fumeus</i>	C.M. 7550a	C.M. 7550b
	<i>Sorex arcticus</i>	C.M. 7549a	C.M. 7549b
	<i>Sorex palustris</i>	C.M. 7548a	C.M. 7548b
	<i>Cryptotis parva</i>	C.M. 7553a	C.M. 7553b
	<i>Blarina brevicauda</i>	C.M. 7545a	C.M. 7545b

larger than the *S. longirostris* used for comparative material. *S. longirostris* is a shrew of the southeastern United States reaching its northern limits on the Atlantic drainage in Maryland. If it is present in the deposit it was not a member of the late Pleistocene, boreal component of the fauna.

Sorex cinereus is primarily an animal of the higher mountain elevations in the state today.

Sorex fumeus Miller—Smoky Shrew

Material: C.M. 7550. 18 mandibles, 2 partial right maxillae.

Distribution: Appalachian Mountains from Georgia north to New Brunswick, west to northern shore of Lake Superior.

Habitat: Moist, cool forest with abundant ground cover, but found in a variety of situations such as bogs and mountain meadows.

Remarks: This is a mountain mammal in Virginia today, occurring at altitudes exceeding 2000 ft. and would not be expected to occur at the site, although it is undoubtedly present on the slopes of North Mountain, five miles west and 1000 ft. higher than Natural Chimneys.

Sorex arcticus Kerr—Arctic Shrew

Material: C.M. 7549. 15 mandibles, 3 partial skulls, 1 palate.

Distribution: Canadian life zone, south to Wisconsin and New Brunswick.

Habitat: Boreal bogs, damp meadowlands in coniferous forests.

Remarks: This is the first record of the arctic shrew from the Pleistocene of the eastern United States although it is known from Illinoian deposits of the Doby Springs local fauna in Oklahoma (Stevens, 1960). Its present southern limit in the Appalachian area is New Brunswick. Fortunately, the specific characters of the skull and mandible are so pronounced that its presence in any cave fauna would not go unrecognized, provided adequate material was preserved.

Sorex palustris Richardson—Water Shrew

Material: C.M. 7548. 7 mandibles, 1 partial skull, 1 rostrum, 1 maxilla.

Distribution: Canadian life zone of North America, south along the crests of the Appalachian Mountains to Tennessee.

Habitat: Along the banks of streams or mountain lakes.

Remarks: Not previously recorded from the state, this shrew may possibly be found living in the higher mountain bogs above 3000 ft.

Microsorex hoyi (Baird)—Pygmy Shrew

Material: C.M. 7554. 1 partial skull, 12 mandibles.

Distribution: Canadian and transition zones of North America, south to the Piedmont of Virginia.

Remarks: Judging from the size of collections, this nominally boreal shrew is one of the rarest of eastern North American mammals. It has only been taken twice in Virginia (Handley and Patton, 1947, p. 109). There is, apparently, only one known modern Pennsylvania specimen, recovered from a fox stomach (Roslund, 1951, p. 40). The pygmy shrew is also known from the New Paris #4 local fauna, Bedford County, Pennsylvania (Guilday and Bender, 1960).

Blarina brevicauda (Say)—Short-tailed Shrew

Material: C.M. 7544-7547. 100 mandibles, 4 partial skulls, 11 maxillae.

Distribution: Central and eastern North America north to the Hudsonian life zone.

Habitat: In a variety of terrestrial habitats wet and dry, from grasslands to dense forest.

Remarks: The short-tailed shrew, the commonest soricid in the deposit, is also the commonest shrew in Virginia today. The average size of the mandibles and teeth in the collection is larger than comparable modern material from Pennsylvania. Some specimens are distinctly larger and more rugged than any modern *B. brevicauda kirtlandi*, and compare favorably with the large late Pleistocene *B. brevicauda* from the New Paris #4 local fauna, Pennsylvania.

Cryptotis parva (Say)—Least Shrew

Material: C.M. 7553. 1 partial skull, 7 mandibles.

Distribution: Central and eastern United States, north to central New York.

Habitat: Grasslands, prairies.

Remarks: The least shrew, in contrast to the other soricids from the deposit, is a field form of southern affinities. It may possibly have postdated the late Pleistocene fauna and is a common mammal in the state today.

Family: Talpidae

Parascalops breweri (Bachman)—Hairy-tailed Mole

Material: C.M. 7540. 3 mandibles, 5 humeri, 2 upper molars.

Distribution: Appalachian Mountains of eastern United States from Tennessee north to Maine, west to north shore of Lake Superior.

Habitat: Well-drained soils irrespective of surface cover, avoids wet situations.

Remarks: The hairy-tailed mole is confined to the mountainous areas of western Virginia today at altitudes of 3000 ft. or more. This mole and *Scalopus aquaticus* do not occupy common ground in Virginia today. Their remains were both present in this deposit but may not have been contemporaneous.

Scalopus aquaticus (Linnaeus)—Eastern Mole

Material: C.M. 7542. 10 mandibles, 5 humeri, 4 partial skulls.

Distribution: Central and eastern United States, north to Michigan and Massachusetts, avoiding the Appalachian Mountain and Plateau region. (See Guilday, 1961, for exception to this.)

Habitat: Well-drained alluvial soils.

Remarks: The common mole at the site today.

Condylura cristata (Linnaeus)—Star-nosed Mole

Material: C.M. 7541. 5 mandibles, 8 humeri.

Distribution: Eastern North America from James Bay and southern Labrador south to Georgia.

Habitat: Wet meadows, bogs, in both coniferous and deciduous forest.

Remarks: Commonest in the mountainous sections of western Virginia today.

Order: CHIROPTERA

Family: Vespertilionidae

Myotis keenii (Merriam)—Keen's Bat

Material: C.M. 7566, 7567. 10 left, 9 right maxillae, 3 partial skulls.

C.M. 7568. 39 right, 21 left mandibles are referred to this species.

Distribution: Newfoundland to southern Alaska, south to Florida.

Remarks: *Myotis grisescens* Howell has recently been reported from fragmentary material found in three West Virginia caves and the Cumberland Cave, Maryland (Handley, 1956, p. 251). Upper dentitions of *M. keenii* are readily distinguishable from those of *M. grisescens*. Lower dentitions, apart from a slightly greater average size, are hard to separate with any degree of confidence. None of the upper dentitions from Natural Chimneys was *M. grisescens*. C.M. 7566, a right maxilla containing C-M³ plus the alveoli of the first two incisors has only two premolars rather than the normal three. It was originally identified as *Plecotus* sp. Closer study indicated that it was an abnormal *M. keenii* with a congenitally missing premolar. This condition is not too rare in the genus (Frum, 1946).

Myotis keenii is not as common in Appalachian caves today as is *M. lucifugus*, the proportion being about 10 *M. lucifugus* to 1 *M. keenii*. It was apparently the commonest bat at Natural Chimneys. It was also the commonest species of bat encountered at the late Pleistocene New Paris #4 local fauna in Pennsylvania (98 *M. keenii*, 54 *M. cf. lucifugus* recovered to date). Could it be possible that *M. keenii* was a more successful species under the boreal conditions of late Pleistocene times in the Appalachians? Perhaps it is significant to note that the young are "probably born later than those of most other bats in the United States". (Hall and Kelson, 1959, p. 167.) Would this adaptation enable it to establish itself as a breeding species in higher latitudes or in harsher climates more successfully than other members of the genus?

Myotis, species ?

Material: C.M. 7569. 1 right, 1 left maxilla. C.M. 7570. 4 right, 1 left mandible. C.M. 7571. 1 right mandible.

Remarks: C.M. 7569 and C.M. 7570 are presumably either *M. lucifugus*, *M. sodalis* or *M. austroriparius*. *M. lucifugus* is the common little brown bat in the area today. *M. austroriparius* is a southern species that has not been taken in Virginia. It would hardly be expected to occur in a deposit containing so many boreal mammals.

C.M. 7571, a right mandible with full dentition broken at the ascending ramus is from an extremely large *Myotis* (C-M₃ is 6.8 mm.). It appears to be larger than either *M. keenii* or *M. grisescens*. In all characters except the depth of the *symphysis mandibuli* and the large canine and premolars it agrees with *M. keenii*. The cingulum of the molars appears lighter than *M. grisescens*. It may be an unusually large *M. keenii*. At some future date, when the bat fauna of the Appalachian Pleistocene is better known, this specimen should be re-examined.

Pipistrellus cf. subflavus (F. Cuvier)—Pipistrelle

Material: C.M. 7572. 1 partial skull, 2 left maxillae, 5 left, 2 right mandibles.
 Distribution: North America, east of the Great Plains, south to Honduras,
 north to southern Quebec.

Remarks: Common at the site today.

Eptesicus cf. grandis (Brown)—Pleistocene Big Brown Bat

Material: C.M. 7563. 1 right, 1 left maxilla, 2 right, 2 left mandibles.

Remarks: See below under *Eptesicus cf. grandis* or *fuscus*.

Eptesicus cf. fuscus (Palisot de Beauvois)—Big Brown Bat

Material: C.M. 7562. 1 palate, 1 left mandible.

Remarks: See below under *Eptesicus cf. grandis* or *fuscus*.

Eptesicus cf. grandis or *fuscus*

Material: C.M. 7564. 1 palate, 1 right, 1 left maxilla, 12 left, 8 right mandibles, all fragmentary. 1 humerus, 1 occipital with partial right zygomatic arch.

Remarks: It is unfortunate that the *Eptesicus* remains from this site are so meager and fragmentary, as they appear to demonstrate intergradation between the large Pleistocene *E. grandis*, (or *E. fuscus grandis*) and the smaller, modern *E. fuscus fuscus*. What appear to be typical examples of both forms (See above) are represented in the collection. Brown, the describer of *grandis*, considered it a subspecies of *E. fuscus*, "probably the direct ancestor of the living *V. fuscus*." (Brown, 1908, p. 175). Gidley and Gazin, 1938, referred the big brown bats of Cumberland Cave, Maryland, to *Eptesicus grandis* and were of the opinion that it was a full species. A single mandible of this form has been recovered from the New Paris #4 local fauna, Pennsylvania, and Handley, 1956, records a mandible from Windy Mouth Cave, Greenbrier, County, W. Va. Unfortunately there is no guarantee that the collection represents a temporal unit population. Perhaps the *grandis* remains predated the *fuscus* material. The final taxonomic interpretation of this collection and the status of the form *grandis* had best be deferred until such time as more Pleistocene faunas are available.

Lasiurus borealis (Muller)—Red Bat

Material: C.M. 7565. 1 partial skull.

Distribution: Southern Canada to Central America, exclusive of the Great Plains and the Rocky Mountains.

Remarks: Although ordinarily considered a tree bat rather than a cave form, remains of red bats are quite often found in cave sites. Common in the area today.

Order: RODENTIA

Family: Sciuridae

Marmota monax Linnaeus—Woodchuck

Material: C.M. 7530. 2 left mandibles, 1 left maxilla, 18 isolated teeth.

Distribution: From Alabama to Labrador, west to Alaska.

Habitat: Found in varied situations, from dense forest to open meadowlands. Prefers well-drained situations for burrow.

Remarks: Common in the area at the present time.

Citellus cf. *tridecemlineatus* (Mitchell)—Thirteen-lined Ground-Squirrel

Material: C.M. 7535. 2 left, 1 right maxillae, 12 molars, 2 partial mandibles.

Distribution: Central Great Plains and upper Mississippi River Valley, from Ohio west to Utah and from Texas to central Alberta and Saskatchewan.

Remarks: The specimens from Natural Chimneys indicate a squirrel slightly more robust than the living form. (Based upon specimens from a feral population in northwestern Pennsylvania in the collections of Carnegie Museum.) This is the first record of the former occurrence of the thirteen-lined ground-squirrel in Virginia. It was reported from the Cumberland Cave local fauna, Maryland (Gidley and Gazin, 1938), and is present in the New Paris #4 local fauna of Pennsylvania. All three localities are well east of its present range. This is a prairie form that avoids the eastern forests entirely and stops at the western margin of the Appalachian Plateau in central Ohio. A feral colony near Polk, Pennsylvania, introduced into a grassland area over 50 years ago, is thriving, but appears limited by wooded conditions; so, apparently, the animal is capable of surviving in eastern areas, provided proper grasslands are available.

Tamias striatus (Linnaeus)—Chipmunk

Material: C.M. 7558-7560. 6 left and 8 right whole or partial mandibles. 6 left, 4 right maxillae.

Distribution: Eastern North America, from James Bay to Georgia and the central Mississippi Valley north to Lake Winnipeg.

Habitat: Forest or forest-edge situations throughout the eastern deciduous forests. Avoids grassland as a rule but is extremely adaptable.

Remarks: Common in the area today. All of the specimens were fragmentary. There appears to have been two size classes present; the smaller comparable to modern Pennsylvania material (C.M. 7558). These may represent the extremes of a single population or, more likely, the sample consists of late Pleistocene and Recent individuals mixed. Their final interpretation lies in a comprehensive study of variation in *T. striatus* that is outside the scope of this paper.

Sciurus carolinensis Gmelin—Gray Squirrel

Material: C.M. 7536. 1 fragmentary maxilla with alveoli of P³-M².

Distribution: Eastern deciduous forests, Florida to southern Ontario.

Habitat: Forest or forest-edge situations of mast or nut-producing trees.

Remarks: Both the gray squirrel and the fox squirrel (*Sciurus niger*) are present today in Virginia but the preserved material was so fragmentary that only this one fragment bearing the alveolus for the characteristic P³ was specifically identifiable.

Sciurus, species ?

Material: C.M. 7537. 1 right frontal, 1 mandible fragment, 15 isolated molars.

Tamiasciurus cf. *tenuidens* (Hay)—Pleistocene Red Squirrel

Material: C.M. 7533. 5 left, 2 right partial mandibles, 2 maxillae, 1 humerus.

Distribution: Extinct. Known from three other Appalachian Pleistocene sites,

Cavetown, Maryland (Hay, 1920), Cumberland Cave, Maryland (Gidley and Gazin, 1938), and New Paris #4, Pennsylvania.

Habitat: Unknown, presumably arboreal, associated with a pollen flora indicating boreal, coniferous parkland at New Paris #4, Pennsylvania (Guilday and Bender, 1960).

Remarks: Distinguishable from modern *Tamiasciurus hudsonicus* (Erxleben) by superior size, more robust appearance, relatively deeper mandible, and greater depth of lower incisor. Compared with referred material from New Paris #4, Pennsylvania in the collection of Carnegie Museum, they showed no differences.

Tamiasciurus, species ?

Material: C.M. 7534. 4 left fragmentary mandibles, 4 fragmentary maxillae, 2 femora.

Remarks: *Tamiasciurus hudsonicus* (Erxleben) is the only species of this genus in the area today. It may possibly be represented in the collection, but the material is too fragmentary to tell.

Glaucomys volans (Linnaeus)—Southern Flying-Squirrel

Material: C.M. 7532. 11 left, 15 right mandibles, 8 maxillae, 4 humeri, 2 femora, 2 radii, 1 frontal.

Distribution: Eastern North America, from Florida to southern Ontario, plus a relict distribution in the mountains of Mexico and Central America.

Habitat: Inhabits a wide variety of forest situations at all altitudes, but does not thrive in Canadian zone situations.

Remarks: This is the only flying-squirrel at the site today. It and the northern flying-squirrel were represented by a minimum of 28 individuals out of a total sciurid collection of at least 50 animals representing 7 species. This is unquestionably due to the hunting activities of the owls that are believed primarily responsible for the bone deposit.

Glaucomys sabrinus (Shaw)—Northern Flying-Squirrel

Material: C.M. 7531. 13 left, 7 right mandibles, 17 maxillae, 5 humeri, 3 femora, 3 frontals, 1 scapula, 1 radius.

Distribution: Hudsonian and Canadian life zone, from Alaska to Labrador, south to Wisconsin and Pennsylvania, plus a relict distribution down the Appalachian Mountains at altitudes exceeding three thousand feet.

Habitat: Forest situation, coniferous or mixed coniferous-deciduous.

Remarks: Specimens are larger and more robust than modern Pennsylvania comparative material. The measurements fall within the range of more northerly modern races (Howell, 1918).

The two flying-squirrels from the deposit are readily separated by size. Modern Pennsylvania examples of *G. s. macrotus* and *G. v. volans* will occasionally overlap in certain cranial measurements (length of lower toothrow, for instance), but the two Natural Chimneys populations did not do so due to the relatively greater size of the *G. sabrinus* from the deposit.

Length of lower tooththrow (P_4-M_3), *Glaucomys*, Natural Chimneys

mm.	6.0	1.1	2.3	4.5	6.7	8.9	7.0	1.2	3.4	5.6	7.8	9.0	1.2	3.4	5.6	7.8	9.0	1.2	3.4	5.6
<i>G. volans</i>			1	7	2	3	2	1	1											
<i>G. sabrinus</i>										1	1	7	1	2				1	3	1

Glaucomys sabrinus has not heretofore been reported from Virginia, although it may yet be taken on some of the higher mountain peaks. Its presence at the site can only be indicative of former climatic change in the area.

A fragmentary mandible from Cumberland Cave, Maryland identified as *Glaucomys* sp., is described as being "about the size of *G. sabrinus*" (Gidley and Gazin, 1938, p. 56). This is the only species of flying-squirrel present in the New Paris #4 local fauna, Pennsylvania. Interestingly enough, the Recent fauna from the New Paris #2 local fauna produced only *Glaucomys volans* (Guilday and Bender, 1958). The species do occur together in some portions of their range today, however, so they could have co-existed at Natural Chimneys.

Family: Castoridae

Castor canadensis Kuhl—Beaver

Material: C.M. 7539. 1 lower incisor, 1 upper molar.

Distribution: Continent-wide.

Habitat: River and stream courses, permanent bodies of fresh water.

Remarks: Re-established in Virginia today.

Castoroides ohioensis Foster—Giant Beaver

Material: C.M. 7538. 1 upper molar.

Distribution: Extinct. Known from many Pleistocene sites throughout the continent, from Alaska south to Oregon, and east to Texas, South Carolina, and New York (Cahn, 1936).

Habitat: Possibly cattail swamps and lakes. Does not appear to have been adapted for tree-felling (Powell, 1948).

Remarks: This appears to be the first Virginia record of the giant beaver.

Family: Cricetidae

Subfamily: Cricetinae

Peromyscus cf. *maniculatus* (Wagner)—Deer-Mouse

Material: C.M. 7508, 7509, 7513. 1 partial skull, 35 left, 32 right mandibles.

Distribution: Most of North America south of the tree line. Avoids the Atlantic coastal plain and the southeastern United States except in the mountains.

Habitat: One subspecies or another occupies almost every terrestrial habitat available within its range.

Remarks: A form larger than *P. m. bairdi*, about the size of modern *P. m. nubiterrae*, is indicated by the dentitions. *P. m. nubiterrae* is the only form of this mouse known from the state. It is restricted to the mountains, in moist woods above 2500 ft. (Handley and Patton, 1947), and does not occur at the Natural Chimneys today. It is not possible to identify the Natural Chimneys specimens to subspecies, but the presumption is that it is most probably a cool

forest race. This would be in harmony with the boreal element of the fauna.

Peromyscus cf. *leucopus* (Rafinesque)—White-footed Mouse

Material: C.M. 7510. 12 left, 7 right mandibles.

Distribution: Temperate North America, east of the Rocky Mountains, south of the Hudsonian life zone. Avoids the southeastern lowlands.

Habitat: Wooded or brushy areas at all elevations.

Remarks: *Peromyscus leucopus* is the only species of deer-mouse at the site today. See remarks under *Peromyscus* sp. below.

Peromyscus, species ?

Material: C.M. 7511, 7512. 94 maxillae, 83 left, 64 right mandibles.

Remarks: Probably *P. maniculatus* or *leucopus* or both. Only unworn first molars were considered diagnostic enough to warrant specific identification. *Peromyscus gossypinus* (LeConte) and *Peromyscus nuttalli* (Harlan) reach the northern limits of their distribution in the state, but neither occurs in Augusta County today, nor do they appear to have been represented in the Natural Chimneys local fauna.

Neotoma floridana (Ord)—Wood-rat

Material: C.M. 7527. Maxillae, mandibles, isolated molars, fragmentary skeletal elements of at least 37 individuals.

Distribution: Southern half of the United States from New Mexico to the Atlantic Coast, north to the Dakotas, Illinois and southern Connecticut.

Habitat: Restricted in the Appalachians to rocky outcrops in forested country at higher elevations.

Remarks: In contrast to the *Neotoma* from the Cumberland Cave local fauna, Maryland (Gidley and Gazin, 1938) and the New Paris #4 local fauna, Pennsylvania, which appears to be larger than the modern *N. f. magister*, the specimens from Natural Chimneys agree in every respect with specimens of *N. f. magister* from Huntingdon County, Pennsylvania. These rats have an affinity for cliff, talus and cave situations and probably lived in the shallow cave. Their habit of accumulating all manner of objects in their living quarters may have been responsible for some of the larger mammal fragments in the deposit, many of which were badly gnawed.

Subfamily: Microtinae

Synaptomys cooperi Baird—Southern Bog Lemming

Material: C.M. 7504. 5 left, 13 right mandibles or isolated M₃s, or both.

Distribution: Northcentral and northeastern United States, south to Arkansas and North Carolina, and southeastern Canada.

Habitat: A variety of grassland situations from sphagnum bog to dry upland clearings in forest or prairie situations.

Remarks: The southern bog lemming is known from two other cave deposits in the Appalachian Mountains: Frankstown Cave, Pennsylvania (Peterson, 1926) and New Paris #4, Pennsylvania (Guilday and Bender, 1960). It has been reported from as far south as San Josecito Cave, Nuevo Leon, Mexico (Jakway, 1958).

Synaptomys borealis (Richardson)—Northern Bog Lemming

Material: C.M. 7502. 3 left, 3 right mandibles.

Distribution: Hudsonian life zone from Alaska to Labrador, south to northern Minnesota and the White Mountains of New Hampshire.

Habitat: Varied; dry, grass-grown, second growth spruce and poplar, thick gloomy spruce woods carpeted with sphagnum, grass clumped willow swamp (Soper, 1942), small meadow, wet swamp, moist spruce woods (Soper, 1948).

Remarks: This is the first state record for the northern bog lemming. Lemmings of the subgenus *Mictomys* are also known from the Cumberland Cave, Maryland (Gidley and Gazin, 1938), New Paris #4, Pennsylvania (Guilday and Bender, 1960), and the Cudahy Fauna of Kansas (Paulson, 1961).

Synaptomys, species . . . *cooperi* or *borealis*

Material: C.M. 7503. 3 partial palates.

Clethrionomys gapperi (Vigors)—Red-backed Vole

Material: C.M. 7517-7519. 18 maxillae, 47 left, 46 right whole or partial mandibles.

Distribution: Hudsonian, Canadian, and Transition life zones from Alaska to Labrador, south in the Appalachian Mountains to North Carolina.

Habitat: Among rocks, under logs, in subsurface burrows in cool, damp forest situations.

Remarks: Although this is one of the commonest small mammals in the collection it does not occur at the site today. In Virginia it is restricted at the present time to areas of cool, moist forest in the mountain ridges but does not reach the floor of the Great Valley. Its presence at the site indicates climatic change. Remains of red-backed mice are known from two other Appalachian cave faunas, Frankstown Cave, Pennsylvania (Peterson, 1926) and New Paris #4, Pennsylvania (Guilday and Bender, 1960).

Phenacomys cf. *ungava* Merriam—Spruce Vole

Material: C.M. 7501. 9 left, 10 right mandibles or M_1 s, or both.

Distribution: Hudsonian and Canadian life zones of Canada, south to northern Minnesota and northern shore of the Gulf of St. Lawrence.

Habitat: Dry, well-drained sites in pine and spruce boreal forest preferred, but in periods of great abundance found in a wide variety of boreal forest habitats (Foster, 1961).

Remarks: This is the second known locality for *Phenacomys* remains in the Appalachian Mountains. It is also known from the New Paris #4 local fauna. Its presence in the late Pleistocene of Virginia implies a range reduction of at least 800 miles from that day to this.

Microtus pennsylvanicus (Ord)—Meadow Vole

Material: C.M. 7520-7525. 5 partial skulls, 40 partial palates. (Most of the 281 mandibles listed as *Microtus* sp. are undoubtedly this species as well.)

Distribution: Northern and central North America south in the east to Georgia and South Carolina.

Habitat: Moist grasslands in open or wooded terrain at any altitude.

Remarks: The commonest small mammal in the deposit, and one of the commonest in eastern North America today.

Vernon Bailey (1900, p. 22) states that the presence of a small, lingually-directed loop following the 5th alternating triangle of M^1 is one of the characters of the Ungava subspecies *Microtus p. labradorius*. As this was well developed in many of the Natural Chimneys specimens, it was believed, at first, that this might constitute a direct genetic link between late Pleistocene Virginia and modern Labrador populations of this vole. A study of 26 skulls from Labrador (Nain, Hebron and Windsor) and 26 from south-central Pennsylvania (Adams, Bedford and York counties) in the collections of Carnegie Museum make it apparent that this character is equally well developed in both modern populations. It may be that a statistical study of this character would reveal a geographic pattern, but this character appears to be of little practical value in attempting to establish modern population equivalents for Pleistocene *Microtus pennsylvanicus*.

Microtus chrotorrhinus (Miller)—Rock Vole

Material: C.M. 7507. 1 partial skull, 1 palate.

Distribution: Hudsonian and Canadian life zones of eastern North America.

Habitat: Among rocks, under logs, in forest situations. Prefers cool, damp situations. Rare and local today.

Remarks: The presence of the rock vole may go unrecorded in a deposit of this nature. Mandibles are indistinguishable from those of *M. pennsylvanicus* except for a slightly smaller average adult size. Upper dentitions can not be identified unless the easily lost M^3 is in place, and in its absence, might be mistaken for *Pitymys*. *M. pennsylvanicus* can be identified as such even if M^3 is missing, and often, due to an incipient lingual loop on M^1 , even when both M^2 and M^3 are missing. With modern specimens or exceptionally well-preserved fossil crania, identification is facilitated. But when the specimens are as fragmentary as they are in this collection it is fortunate that two upper dentitions were complete enough to be identified as rock vole. The apparent ratio of 45 *M. pennsylvanicus* to 2 *M. chrotorrhinus* more probably reflects, not the relative abundance of the two species in the area at the time the site was an active owl roost (assuming the two species to be equally vulnerable to predation), but the relative ease with which fragmentary remains of these two species can be identified. Since the habits of *M. chrotorrhinus* probably do serve to protect it from owl predation to a greater extent than the meadow-inhabiting *M. pennsylvanicus*, it may not have been a rare mammal in the vicinity of the Chimneys. This species has not been recorded from Virginia during recent times although it has been trapped within 10 miles of the state line in West Virginia (Handley and Patton, 1947, p. 174). The presence of *M. chrotorrhinus* at the altitude of 1357 ft. in Virginia is indicative of former climatic change. It occurs at altitudes of over 3000 ft. in the central and southern Appalachians today.

Microtus pennsylvanicus or *chrotorrhinus* or both

Material: C.M. 7514, 7515. 169 left, 138 right mandibles or M_1 or both.

Remarks: *Microtus pennsylvanicus* is a larger species, but the range of individual variation in modern specimens often exceeds the specific variation.

Microtus xanthognathus (Leach)—Yellow-cheeked Vole

Material: C.M. 5861, 7526. 24 mandibles, 5 palates, 1 maxilla, isolated molars.

Distribution: Hudsonian life zone, western Canada and Alaska, east to Hudson Bay.

Habitat: A variety of grassland and boreal forest situations, wet or dry; appears to prefer the near presence of water, an extensive burrower.

Remarks: Pleistocene remains known only from this site and from New Paris #4, Pennsylvania (Guilday and Bender, 1960).

cf. *Pitymys pinetorum* (LeConte)—Pine Vole

Material: C.M. 7505. 53 left, 65 right mandibles.

Distribution: Eastern United States west to the Great Plains, north to Wisconsin and southern Maine.

Habitat: A burrower in loose friable soils in field or forest.

Remarks: In the absence of more complete cranial material, the possibility of the presence of the prairie vole, *Pedomys*, can not be completely excluded. The identification of *Pitymys pinetorum*—highly probable since it is one of Virginia's commonest small mammals today—must therefore remain provisional. *Microtus* (or *Pedomys*) cf. *involutus* (Cope) has been reported for Cumberland Cave, Maryland. These specimens I consider to be most probably *P. pinetorum*. *Pitymys pinetorum* based upon adequate cranial material is known from the New Paris #4 local fauna, Pennsylvania.

Ondatra zibethicus (Linnaeus)—Muskrat

Material: C.M. 7506. 5 left, 6 right partial mandibles or M_1 or both, 2 partial palates, isolated molars and post-cranial scraps.

Distribution: Most of North America, north of the lower Austral life zone.

Habitat: A wide variety of aquatic habitats from trout streams to salt marshes.

Remarks: Common in the area today.

Family: Zapodidae

Zapus hudsonicus (Zimmermann)—Meadow Jumping-Mouse

Material: C.M. 7528. 11 left, 13 right mandibles, 5 maxillae.

Distribution: Alaska to Labrador, south in the east to Georgia and Alabama.

Habitat: Grasslands, brushy meadows, swamps.

Remarks: Common in the state at all elevations.

Napaeozapus cf. *insignis* (Miller)—Woodland Jumping-Mouse

Material: C.M. 7529. 4 left, 9 right mandibles, 5 maxillae.

Distribution: Eastern North America from southern Manitoba to southern Labrador, south along the Appalachian Mountains to northern Georgia.

Habitat: Grassy swales, moist, cool forest situations near water.

Remarks: The woodland jumping-mouse is apparently confined to mountain forests in the state today. In the higher ridges it is not an uncommon animal, but it does not occur at the site today. The fragmentary specimens from the Natural Chimneys deposit are larger and more robust than comparable modern Pennsylvania specimens of *N. i. insignis*, and agree in size with the *Napaeozapus* material from the New Paris #4 local fauna. The fragmentary mandible from the Cumberland Cave deposit (Gidley and Gazin, 1938) is apparently larger than modern material as well. Modern populations of this animal seem to show a clinal increase in size towards the north, and the somewhat greater size of these late Pleistocene animals may have been in response to a harsher climate at the time of deposition.

Family: Erethizontidae

Erethizon dorsatum (Erxleben)—Porcupine

Material: C.M. 7543. 3 isolated molars, at least 2 animals.

Distribution: Alaska to Labrador, south along the Appalachian Mountains to Tennessee.

Habitat: Requires woody vegetation, but is extremely adaptable to a variety of habitats from mountain to desert. In eastern United States restricted to the Canadian and Transition zone forests.

Remarks: There appears to be no recent record for the porcupine in the state of Virginia (Handley and Patton, 1947, p. 185). Porcupine remains have been reported from Cavetown and Cumberland caves, Maryland, as well as numerous Pennsylvania cave deposits (Hay, 1923).

Order: LAGOMORPHA

Family: Leporidae

Lepus cf. americanus Erxleben—Snowshoe Hare

Material: C.M. 7556. 1 innominate, 2 ulnae, 1 radius, 1 parietal, 3 frontals, 1 mandible fragment.

Distribution: Hudsonian and Canadian life zones of North America, south to Pennsylvania. South to Tennessee in the higher ridges of the Appalachian Mountains.

Habitat: Coniferous forests, bogs, coniferous-deciduous boreal or mountain woodlands.

Remarks: Confined to the higher mountain ridges of the state, this animal is rare and local today. It was not a member of the Recent fauna at Natural Chimneys. At least three animals are represented in the fragmentary leporid material from the site. Identification was based upon the shape of the postorbital processes of the frontals, the absence of a parietal-interparietal suture, the coronoid process of the mandible, and the shape of the ischium. Remains of snowshoe hares are common in Pleistocene cave deposits in the central Appalachians. They have been reported from Cumberland Cave, Maryland, Frankstown Cave and New Paris #4, Pennsylvania.

Sylvilagus, species ?—Cottontail Rabbit

Material: C.M. 7555. 1 tibia, 1 radius, 1 left mandible, 1 pair of frontals.

Remarks: Probably either *S. floridanus* or *S. transitionalis*, but the specimens were too fragmentary to identify to species.

Leporidae, genus and species

Material: C.M. 7557. Fragments representing a minimum of 13 animals.

Remarks: Undoubtedly a mixture of *Sylvilagus* and *Lepus* as above, but too fragmentary to identify beyond family.

Order: CARNIVORA

Family: Canidae

Canis cf. *lupus* Linnaeus—Wolf

Material: C.M. 7573. 1 right M₂, unerupted; 1 ungual phalange, adult.

Distribution: North America continent from central Mexico to Alaska. Common in Virginia during historic times, now exterminated.

Remarks: The tooth agrees with modern comparative material of *Canis lupus lycaon*, but is not diagnostic enough to rule out the possibility of domestic dog. Wolf is highly probable, however, due to the age of the fauna and absence of any obvious feral or domestic animals from it.

Canidae, species—Fox

Material: C.M. 7588. 1 left deciduous P⁴.

Remarks: The tooth is unworn and broken, only the paracone and metacone are preserved. It was from a fox, most probably *Urocyon* or *Vulpes*.

Vulpes sp. Red ? Fox

Material: C.M. 7482. 1 right P⁴. Fig. 4, A and D.

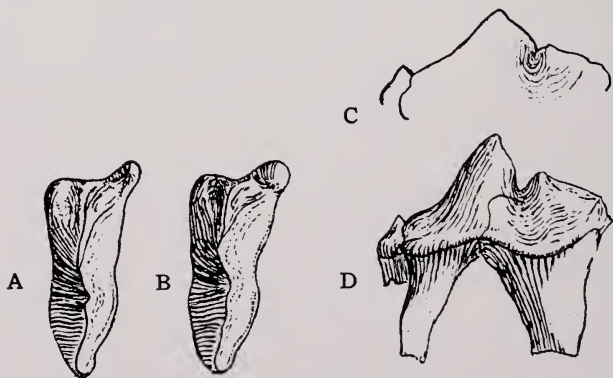


Fig. 4. Right upper fourth premolar, *Vulpes* sp. Natural Chimneys local fauna, A. crown view, D. buccal surface. Right upper fourth premolar, *Vulpes fulva* C.M. mammal 7451. B. crown view. C. buccal surface 2×

Remarks: The tooth is complete and unworn. The roots are open, but in the process of closing. Comparison was made with modern specimens of *Alopex*, *Urocyon* and *Vulpes*. The tooth appears to be from a

fox of the genus *Vulpes*, but it can not be matched with modern specimens of *V. fulva* from eastern North America nor with modern *V. velox* or *V. macrotus*.

The specimen was examined by Charles O. Handley, Jr., U. S. National Museum, who reports: ". . . it is most like *Vulpes fulva*, particularly like specimens from eastern Canada (Labrador and Ontario). Although I would hesitatingly refer it to *Vulpes*, I would not say that it is *Vulpes fulva*. . . . the cusps are more trenchant, the deutercone is smaller, the whole tooth, and particularly the parastyle, is narrower, and the carnassial notch is more open.

"Although the size of the deutercone and the width of the tooth are relatively the same in this specimen and in *Vulpes velox* and *Vulpes macrotus*, there are other significant differences. The Natural Chimneys tooth is larger, cusps are more trenchant, carnassial notch is more open, parastyle is slightly narrower, and metastyle is notably longer and lower." (Letter, Jan. 3, 1962).

Two Pleistocene red foxes have been described from eastern North America. *Vulpes latidentatus* Cope, 1899, from Port Kennedy Cave, Pennsylvania is represented by a single M¹ and may be invalid. *Vulpes palmaria* Hay, 1917, from Florida is known only from mandible and skeletal fragments (Ray, 1958, p. 435). The type materials, therefore, can not be compared directly, nor can either, with the Natural Chimneys specimen. Until such time as better fossil material becomes available, this specimen can not be identified to species, although the characters discussed are quite pronounced. Measurements in mm. C.M. 7482. *Vulpes* sp. right P⁴. Length of crown . . . 14.8 mm. Maximum width of crown . . . 5.6 mm.

Family: Ursidae

Ursus cf. *americanus* Pallas—Black Bear

Material: C.M. 7574. 1 right M₃.

Distribution: Formerly most of the continent south of the tree limit. Common in Virginia at all elevations within historic times.

Remarks: Tooth identical to Pennsylvania specimens of *Ursus a. americanus*.

Family: Procyonidae

Procyon cf. *lotor* (Linnaeus)—Raccoon

Material: C.M. 7575. 2 canines, 1 incisor, 1 deciduous P³, 1 upper premolar.

Distribution: Continent-wide south of the boreal forest. Common in Virginia today.

Family: Mustelidae

Martes americana (Turton)—Pine-Marten

Material: C.M. 7613. 1 humerus, 1 ulna.

Distribution: Canadian and Hudsonian life zones of North America, south along the Appalachian crests formerly as far south as Virginia. No modern record of the animal in Virginia.

Habitat: Coniferous forests, preying primarily on hare and squirrel. Semi-arboreal.

Remarks: This appears to be the first record of the pine-marten from Virginia.

Martes pennanti (Erxleben)—Fisher

Material: C.M. 7576. 1 P¹, 1 M¹.

Distribution: Formerly throughout most of forested North America south to the Austroriparian life zone.

Habitat: Varied situations in coniferous forest primarily, highly arboreal. A squirrel and rabbit predator.

Remarks: Formerly present in the mountain ridges of the state.

Mustela rixosa (Bangs)—Least Weasel

Material: C.M. 7577. 1 fragmentary left maxilla with dentition, 1 fragmentary left mandible.

Distribution: Northern and central North America south to Ohio, in the Appalachian Mountain region from Pennsylvania south to North Carolina.

Remarks: This animal is so erratic in distribution and choice of habitat that its presence in the deposit has little ecological implication. It is apparently restricted to the mountains of the state today. The specimens, judging from their size, are from female animals.

Mustela cf. *rixosa* or *erminea*—Weasel

Material: C.M. 7578. 4 left, 2 right mandibles, 2 left maxillae.

Remarks: None of the specimens is complete or with full dentitions. Although *M. erminea* is the larger species, the difference in size between the sexes is so great that an isolated mandible of a male *M. rixosa* may equal or exceed that of a female *M. erminea*. (See C.M. 24,918, *M. rixosa allegheniensis* and C.M. 31,206, *M. erminea cicognanii*). The mandible of *M. erminea* is relatively longer and slimmer, and the premolars are relatively larger, but without any knowledge of the sex of the animals represented by the fragmentary specimen from Natural Chimneys, specific identification is uncertain. *M. erminea* is not known from modern Virginia, but at one time it did occur south of its present southern limits, in the Conard Fissure, Arkansas. (Brown, 1908).

Mustela frenata Lichtenstein—Long-tailed Weasel

Material: C.M. 7579. 3 left, 1 right mandible.

Distribution: Mexico, United States, southern Canada.

Habitat: Varied, field or forest.

Remarks: The common weasel in the state today.

Mustela vison Schreber—Mink

Material: C.M. 7580. 2 left, 1 right P¹, 1 left, 1 right M¹, 1 C, 1 M₁.

Distribution: Most of North America exclusive of the arid southwest and Mexico. Common in Virginia today.

Habitat: Semi-aquatic.

Mephitis mephitis (Schreber)—Skunk

Material: C.M. 7581. 1 left temporal, premaxillae, partial right mandible.

Distribution: Throughout most of North America south of the tree line. Occurs at the site today.

Family: Felidae

Material: C.M. 7582. 1 penultimate phalange.

Remarks: The characteristic excavation for the reception of the sheathed ungual phalange was present. This was a small animal, possibly a small *Lynx* or a large domestic *Felis*.

Order: ARTIODACTYLA

Family: Tayassuidae

Mylohyus, species ?—Long-nosed Peccary

Material: C.M. 7584, 7586. 2 partial molars, 3 molar fragments, partial right nasal.

Habitat: Associated with a boreal fauna and pollen flora at New Paris #4 local fauna, Pennsylvania.

Remarks: *Mylohyus* remains have been recovered in many Appalachian cave deposits. This peccary occurred in the boreal New Paris #4 local fauna and survived the Wisconsin glaciation to become extinct within the last 10,000-11,000 years (Guilday and Bender, 1960).

Family: Cervidae

Odocoileus cf. *virginianus* (Zimmermann)—Virginia Deer

Material: C.M. 7585. 12 teeth, 2 metapodial fragments, 2 petrous temporals.

Distribution: Most of forested North America, a common Virginia mammal.

Remarks: Both deciduous and permanent teeth are represented.

Cervidae, species ?

Material: C.M. 7586. A partial unerupted incisiform tooth, possibly *Cervus*.

Age of the Natural Chimneys Local Fauna

The fauna is not a temporal unit, but its probable chronological limits seem clear. Introduced species, such as the rat (*Rattus*) or the house mouse (*Mus*), or any domestic mammals are not present. Equally illuminating is the lack of any mammalian species the range of which does not extend as far north as the site today. The spotted skunk (*Spilogale*), and the opossum (*Didelphis*), two mammals common in western Virginia, but suspected of being post-Pleistocene additions to the mammal fauna of the state, are absent. It seems probable then that the fauna is pre-Columbian and, in the light of the complete lack of southern mammals, that it pre-dates the period of post-Pleistocene warming known as the Climatic Optimum. The presence of such ecological incompatibles as the yellow-cheeked vole (*Microtus xanthognathus*) and least shrew (*Cryptotis*) makes it probable that the deposit took thousands of years to accumulate.

Of the 55 species of mammals recorded from the site, four are extinct: the giant beaver (*Castoroides*), the peccary (*Mylohyus*), the squirrel (*Tamiasciurus tenuidentis*) and the bat (*Eptesicus grandis*). All these are known to have survived into post-Wisconsin times (Powell, 1948; Guilday and Bender, 1960). All of the remaining species either occur at the site today or have retreated to higher elevations or latitudes with the onset of post-glacial warming. The presence of such boreal forms as the spruce vole (*Phenacomys*), the northern bog lemming (*Synaptomys borealis*), the yellow checked vole (*Microtus xanthognathus*), and the arctic shrew (*Sorex arcticus*) is clear evidence that deposition was taking place at or near the height of a glacial advance. All of these

boreal forms are present in the New Paris #4 local fauna which has a carbon 14 date of $11,300 \pm 1000$ years (Yale Radiation Laboratory No. 727). The collared lemming (*Dicrostonyx hudsonius*), known from the New Paris #4 local fauna, is missing from Natural Chimneys (Guilday and Doult, 1961). This may indicate a later date for the beginning of deposition at the latter site or, more probably, that the collared lemming did not occur as far south as Natural Chimneys during the Pleistocene. Otherwise the faunal correlation between the two sites is firmly established and they are probably very close in time. The Natural Chimneys fauna includes some temperate forms that New Paris #4 does not: the shrew (*Cryptotis parva*), the squirrels (*Sciurus carolinensis* and *Glaucomys volans*), the box turtle (*Terrapene carolina*), and probably the deposit kept accumulating during that period when temperate forms were reoccupying the area.

The deposit appeared to have no stratigraphic sequence so it is not possible to state categorically which of the component species were or were not contemporaneous. The geological evidence, the condition of the bones, the unconsolidated matrix, all seem to be compatible with the faunal evidence and point to an early post-Wisconsin age for the Natural Chimneys local fauna.

Climatic Interpretations

The Natural Chimneys local fauna is so late in time that many of its component species are still living. Environmental inferences concerning the time period involved can be drawn from a study of the modern habitat requirements of such forms. However, the temptation is great to attempt to infer too much.

The geographic ranges and the ecological requirements of organisms vary enormously from species to species, often within the same genus. In certain cases such as a parasitic or an insular form, limiting factors may be clear-cut. But in most cases they are far from clear and so interwoven into the total ecological fabric that they can not be studied individually without losing much of their significance.

One handicap is the necessity of viewing a continuously evolving process from a single point in time. The reason an animal is found in a particular spot today, while it certainly includes the sum of the environmental pressures acting on it at the present time (after all, the animal directly involved is living now, not yesterday) also includes processes and changes that have been in operation, some for millennia.

We also have an incomplete picture of the modern ecological requirements of many of the commonest of mammals. The less that is known of an animal's habitat requirements, the easier it is to be dogmatic about them. The meadow vole, *Microtus pennsylvanicus*, for example, is a grasslands form closely confined to a ground cover of grass or sedge. But this may include such diverse situations as tidal swamps or boreal bogs, extensive meadowland or tiny isolated mountain glades set in dense upland forests both coniferous and deciduous. Although this mouse is limited to grassy areas, such areas may be unrelated and incidental to the regional picture.

The smoky shrew in Virginia today is restricted to cool, moist Transition and Canadian zone forest in mountainous terrain with an understory of ferns and mosses. This is usually the "habitat" that one associates with the animal throughout its range. But Harry R. Roslund (1951), working in central

Pennsylvania, found this shrew, "Common in *Synaptomys* runways in brushy fields of poverty grass. None were taken in hemlock and rhododendron growing in deep humus among sandstone boulders near one of these fields." (Where the author apparently *expected* them to be.)

Other forms such as the big-tailed shrew or the rock vole are severely limited or perhaps highly adapted to areas of rocky talus and are rarely taken elsewhere.

There is a temptation to overstress the ecological implications inherent in the presence of a given species in a Pleistocene fauna, based upon its modern habitat preferences. I can not give much weight to the suggestion that perhaps the ecological requirements of a certain living form were quite different in the past. As the geological age and the taxonomic disparity of faunas increase it becomes more and more hazardous to assume past environmental situations from modern habitat preferences. But when dealing with late Pleistocene forms one is probably safe in assuming that any temporal change in the habitat preferences of a given species has been minimal from that day to this.

The danger lies in the assumption that because a certain species was found in a Pleistocene deposit the habitat was therefore *typical* of that in which the animal occurs today. It may in fact have been marginal and atypical. A muskrat, for example, was recovered from the New Paris #2 sink-hole on a dry hillside a mile from the nearest stream (Guilday and Bender, 1959). When dealing with a fossil occurrence, we can not see the total contemporary range of the form as can be done with modern specimens. We can not even infer too much from the relative numbers of the various forms in a fossil fauna. Sampling error, mode of deposition, methods of recovery, ease of identification, all influence the relative abundance of the component species. This may be quite a different picture from the situation as it actually existed.

The picture improves when an assemblage of species having roughly the same habitat requirements or geographic distribution occur together in a deposit. The chances of an atypical habitat decrease as the size of the recovered fauna increases. It is hard to imagine a considerable segment of a fauna living atypically.

The Natural Chimneys local fauna is rich enough, both in species and in individual animals represented, however, so that its climatic implication seems quite clear.

A summary of the modern climate and environment of the area will serve as background for the climatic deductions to follow.

Modern Climate of Virginia

The present climate of Virginia is temperate and relatively humid; average rainfall is 43.63 inches, varying from 8.8 inches in the fall to 13.22 inches, during the summer months (Hibbard, 1941); average temperature is 59° F., with a winter mean of 40° F. and a summer mean of 77° F.

In a state as rugged as Virginia, however, average figures have little significance. Relief varies from sea-level to the 5720-ft. summit of Mt. Rogers. Temperatures may vary as much as 5° F. per 1000 ft. of ascent during the summer and 2° F. per 1000 ft. during the winter. The lowest temperature recorded at Onley, Virginia at sea-level was -3° F. but temperatures as low

as -44° F. have been recorded in the Virginia and West Virginia mountains at the same latitude but 4000 ft. higher (Brooks, 1943).

During the cooler part of the year Virginia's weather is determined by cyclonic air masses sweeping across the continent from west to east, producing a variable day-to-day succession of weather. Weather patterns in the summer are influenced by warm, moist, tropical air masses. Snowfall is directly correlated with altitude and may be quite heavy in the mountains. Snow never lingers throughout the year. In some sections of the Virginia and West Virginia Appalachians (the Cheat Mountains, W. Va., Brooks, 1943) frosts have been recorded as late as July.

Biotic Zonation in the Virginia and West Virginia Appalachian Mountains

The varied climate and topography of the area today is expressed in the vertical zonation of its plants and animals. Despite the many theoretical objections to the Merriam life zone concept, the practical application of life zones in studies of altitudinal distribution is well established and will be used here with the proviso that these zones merge quite imperceptively and irregularly into one another in the southern Appalachians.

With the exception of the lowland tip of southeastern Virginia, which is in the Austroriparian life zone, most of Virginia east of the Blue Ridge lies in the Carolinian life zone. The floor of the Shenandoah Valley and of deep mountain valleys farther west is also Carolinian. This zone occupies the valley floors up to 1500 ft. and in open country ascends to 2000 ft. Its upper limit may dip as low as 1200 ft., however, in forested ravines (Murray, 1945). All of the mountains, with the exception of a few mountain summits above 4000 ft., lie in the Alleghenian or Transition zone. In the mountains of West Virginia the upper limits of the Alleghenian lie at about 3500 ft. According to Murray, the theoretical upper limits of the Alleghenian life zone should lie between 3000 and 3500 ft. in Virginia but it approaches 4500 ft. on Apple Orchard Peak and Elliott's Knob. Zonation is not a simple function of elevation here but varies altitudinally with slope exposure, air drainage, local precipitation and edaphic factors. "While there is a good deal of Canadian zone territory in the high Allegheny Plateau of West Virginia [700,000 acres before logging, Brooks, 1943, p. 25], and a fair area of it on the great peaks of the Smokies along the North Carolina and Tennessee line there is little or no territory in Virginia which can be called pure Canadian. On White Top and Mt. Rogers, the two highest mountains in Virginia, which reach 5519 and 5720 ft., respectively, we have some small areas which are practically Canadian, and on Middle Mountain in Highland County we have some territory that approaches it." (Murray, 1945, p. 20). After logging, the Canadian zone spruce stands are replaced by Transition zone mixed hardwood-coniferous forest, so the original extent of the state's Canadian zone was undoubtedly somewhat larger than it is today.

The lower limit of the Canadian zone in the Virginia and West Virginia mountains varies considerably. Depending upon local factors it ranges from 3300 ft. (Cranberry Glades, W. Va.) to 4500 ft. (Elliott's Knob, Va.).

Maurice Brooks (letter) is of the opinion that the upper limit of the Canadian zone in the West Virginia mountains would lie between 6000 and 7000 ft. assuming the mountains were that high. Thus we see that in Virginia

today typical Canadian zone conditions either do not exist or are restricted to the highest mountain summits.

Climatic Implications of the Natural Chimneys Local Fauna

The presence of such typical Canadian zone species as the water shrew, the arctic shrew, the snowshoe hare, the pine-marten, the northern flying-squirrel, the northern bog lemming, the spruce vole, the yellow-cheeked vole, the rock vole, the spruce grouse and the gray jay in a cave deposit at 1357 ft. on the floor of the Shenandoah Valley in what is now the Carolinian life zone, indicates a lowering of life zones during late Wisconsin time. There is no reason to assume that biotic zones (similar but not necessarily identical to those of today), were not in existence throughout the late Pleistocene at least. Martin, (1958, p. 383), acting upon this assumption, has constructed a map of the probable life zone situation in eastern North America during full glacial conditions, 18,000 years ago. Although of necessity quite generalized, this model, based primarily upon palynological evidence, agrees quite well with the faunal evidence. The presence of the tundra rodent, *Dicrostonyx* at the New Paris #4 local fauna in southcentral Pennsylvania, and its apparent absence at Natural Chimneys, agrees with Martin's mapping of the tundra and taiga (Hudsonian) zone. Lowland Virginia he places in the boreal forest (Canadian zone), but postulates tundra and taiga conditions on the Appalachian crests.

In order to bring Canadian zone species to the altitude of Natural Chimneys today it would be necessary to depress the lower limits of the Canadian life zone in Virginia by at least 2000 ft. This would place the crests of the Appalachians above timber-line, as Martin's map would indicate. The actual depression may have been even greater. Martin, (1958, p. 382) suggests 4000 ft. This would still be compatible with the Natural Chimneys fauna. In fact, the presence of such distinctly boreal forms as the spruce vole, the northern bog lemming, the yellow-cheeked vole and the arctic shrew is indicative of drastic climatic change beyond the minimum required.

What this implies, of course, is cooler conditions. The presence of the water shrew, smoky shrew, arctic shrew, red-backed vole, and the rock vole would require wetter conditions than occur at the site today. Winters were probably long and severe, summers cooler and very moist. It is conceivable that the broad flat North River valley may have been an extensive boreal bog, affording a vast collecting area for the owls of the Natural Chimneys to draw from. The high incidence of flying-squirrels requires forest cover, but the extremely high proportion of microtines indicates the presence of grasslands as well. The presence of the thirteen-lined ground-squirrel is as yet enigmatic. It is an inhabitant of dry, short-grass prairie in the mid-west, but is known to have occurred at Cumberland Cave, Maryland (Gidley and Gazin, 1938) and during late-Wisconsin times in Pennsylvania (Guilday and Doult, 1961). It is probable that deposition of these bones lasted well into early Recent times but halted before any "Climatic Optimum" range changes could be recorded (The presence of the coachwhip snake, 1 vertebra, and the diamond-backed rattlesnake, 1 vertebra, might be interpreted as such evidence, however).

In summary, the valleys of western Virginia during or shortly following the last glacial advance were probably covered by a coniferous forest inhabited by snowshoe hares, red squirrels, porcupines and pine-marten. Water shrews lived

along the streams that supported muskrat, beaver, and possibly, giant beaver. Long-nosed peccary still roamed the district. A variety of boreal rodents lived in the swampy grasslands. The spruce grouse, the gray jay, the magpie, the northern flying-squirrel, and the red-backed vole lived in these lowland forests. Thirteen-lined ground-squirrels may have occupied the burns resulting from natural forest fires,* sharing these areas with the sharp-tailed grouse. The mountain summits at this time can be envisioned as open barrens, snow-covered most of the year. Outcrops of actively weathering rock clogged the roaring mountain torrents with beds of frost-wedged boulders. The tree line occurred somewhere on the mountain slopes, ascending ever higher as the ice receded. As the Canadian forest ascended the mountains, it was replaced in the warming lowlands by the temperate forest trees of today. Post-glacial warming has forced the Canadian zone spruce up to the highest mountain summits in Virginia where it still clings, a relict of former days.

Summary

See map, Fig. 5, page 119.

A late Pleistocene and early Recent fauna of at least 14 species of invertebrates and 120 species of vertebrates was recovered from caves at the Natural Chimneys, Mt. Solon, Augusta County, Virginia. These fragmentary bones and teeth constitute the Natural Chimneys local fauna. Many of the species are found only in the Canadian and Hudsonian life zones today, some survive only in Canada, four are extinct.

They are indicative of a boreal climate on the floor of the Shenandoah Valley of Virginia during late glacial times ca. 10,000-15,000 years ago. The lower limit of the Canadian life zone appears to have been depressed at least 2000 ft. to include all of the western valley floors of the state.

* I am indebted to P. S. Martin for this suggestion.

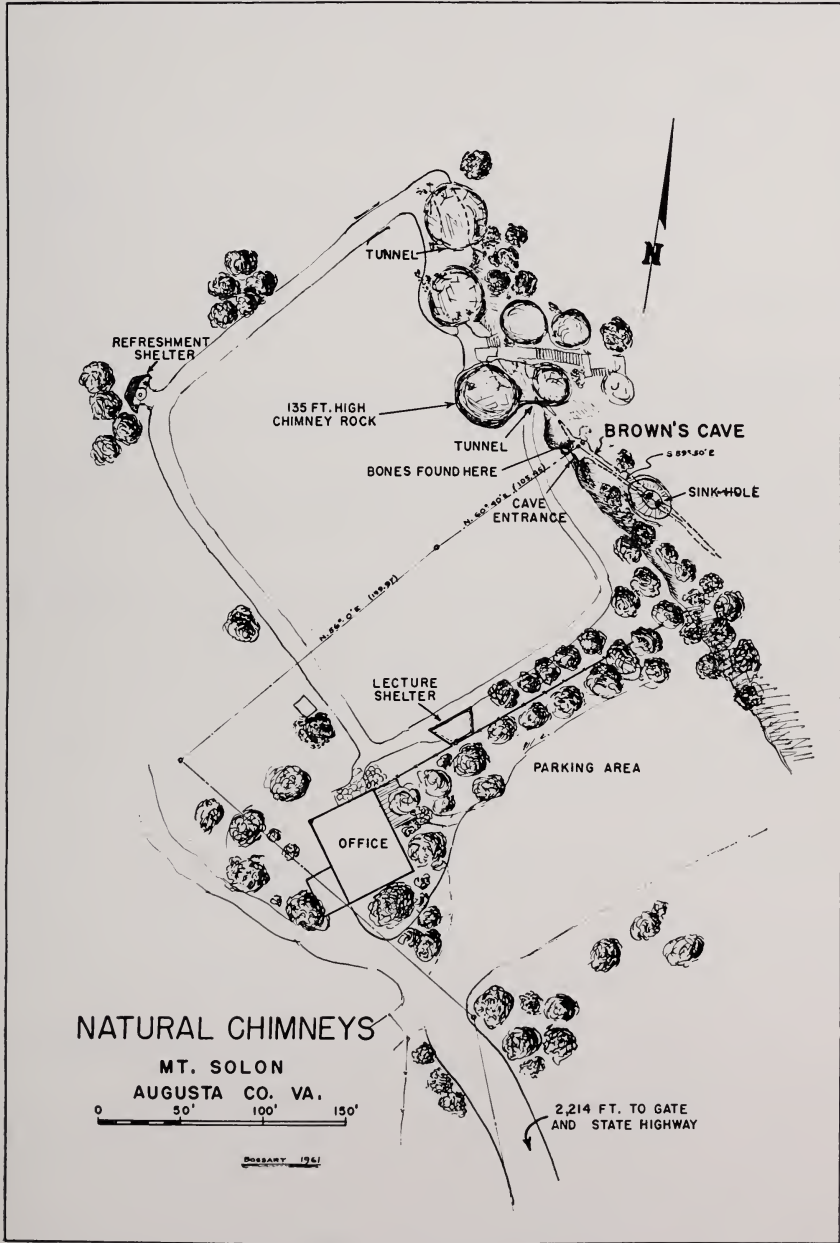


Fig. 5. Map of Natural Chimneys, Mount Solon, Virginia

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ART. 10. A NEW EUOMPHALID GASTROPOD FROM THE CONEMAUGH FORMATION, PENNSYLVANIAN

By J. J. BURKE

The various species of euomphalid gastropods have been of particular interest to workers in Pennsylvanian stratigraphy since Knight (1934) followed by Moore and others (1944) called attention to the possible value of these forms as index fossils. The new species described below, which has been noted previously (Burke, 1958) as characterizing the Carnahan Run member of the Conemaugh formation, Pennsylvanian, may eventually prove to have limited vertical distribution in the Conemaugh. It also throws some light on trends within the subgenus *Amphiscapha*.

I am much indebted to various institutions and their representatives for assistance in carrying on this study. These include the United States National Museum and Dr. G. A. Cooper, Head Curator of Geology, for the privilege of examining collections and of borrowing and exchanging specimens. Dr. E. L. Yochelson of the United States Geological Survey has generously helped me by discussion and by placing specimens at my disposal for study. The Carnegie Museum, through Director Dr. M. Graham Netting, in addition to providing for the publication of this paper, has given me full access to its study collections and facilities. Dr. E. R. Eller, for whom the new species is named, has kindly loaned me literature from his personal library and given me much encouragement in the work. I am very grateful to Mr. Raymond Patalski of the Applied Research Laboratory of the United States Steel Corporation for the photographs from which the illustrations were taken.

All of the fossil material upon which the present description is based is from my personal collection and has been given to Carnegie Museum.

SYSTEMATIC PALEONTOLOGY

Family Euomphalidae Koninck, 1881

Genus *Amphiscapha* Knight, 1942

Subgenus *Amphiscapha* Knight, 1942

Amphiscapha (Amphiscapha) elleri sp. nov.

Fig. 1, A-N

Diagnosis: Smallest known species of *Amphiscapha* (maximum width about 10 mm.); elevation of final whorl moderate; upper and lower faces of mature whorls usually flattened or slightly concave; upper angulation a weak, crenulated carina; lower angulation a distinct but narrow bourrelet; outer whorl face more rounded in profile than in *Amphiscapha catilloides* (Conrad) or *Amphiscapha reedsi* (Knight) and tending to expand beyond base in late maturity and old age.

Types: Holotype, Carnegie Museum Catalogue of Invertebrate Fossils No. 28728; paratypes, Carnegie Museum Catalogue of Invertebrate Fossils No. 28729, 28730 and 28731.

Referred Specimens: Two polished thin sections, Carnegie Museum Catalogue of Invertebrate Fossils No. 28732 and 28733 (both figured); twelve other specimens, Carnegie Museum Catalogue of Invertebrate Fossils No. 28607 through 28618 (unfigured).

Occurrence: Carnahan Run member, Conemaugh formation, Pennsylvanian.

Locality: All specimens collected from the Carnahan Run member at Gosser Hill, Westmoreland County, Pa., across the Kiskiminitas River from Leechburg, Pa.

Description: This species comprises discoidal gastropods closely related to *Amphiscapha catilloides* (Conrad) and similar to the latter species in coiling habit. The spire and base are both often gently concave, although sometimes the base is flat, but the effect can be misleading and due to compression.

The shell is composed of approximately $5\frac{1}{2}$ whorls, of which about $2\frac{1}{4}$ whorls make up the protoconch, which is simple externally, but internally bears septa or partitions. The septa in this species vary in number from one to five, insofar as I can determine, and appear to be confined to the protoconch. Full maturity in *Amphiscapha elleri* appears to have been reached after about $5\frac{1}{4}$ whorls; the subsequent stage, as indicated by coarsening and irregularity in lines of growth coupled with a somewhat inflated appearance of the final quarter of the body whorls, seems to be characteristic of old age. None of my specimens exceeds 10 mm. in width at this latter stage, and it seems fair to assume that this was close to the maximum width for the species.

The upper sutures are linear to grooved. The upper whorl surface curves up from the suture and inclines outward approximately 15 degrees from vertical, then bends about 20 degrees from the horizontal in the mature stage, or 30 degrees in the subsequent growth stage, to terminate at the upper angulation. This surface becomes flattened or slightly concave at one-fifth the width of the whorl face from the suture at maturity, or at about one-eighth of the distance at later stages of growth, when the effect is most evident. The surface steepens as it approaches the upper angulation, but grades indistinctly into the carina, which is relatively inconspicuous and ornamented with low, irregular crenulations.

The outer whorl surface becomes slightly concave below the upper carina, forming a very shallow sulcus. From the sulcus, the surface inclines outward some 50 degrees from the vertical in mature individuals, or 30 degrees in older specimens, reaching the periphery near midheight in the mature stage and at about two-fifths the height in old age. The whorl surface then bends inward as much as 20 degrees in mature and about 10 degrees in advanced stages of growth becoming slightly concave as it approaches the base and forming a shallow lower sulcus.

The lower angulation consists in a relatively narrow bourrelet; it is not drawn out to form a carina or keel, and it is better described as a rounded edge with irregular undulations, rather than crenulations.

The bourrelet walls the basal whorl face; internal to it the whorl face is sometimes slightly convex, but more often flattened or somewhat concave. The basal sutures are linear.

These shells are widely phaneromphalus. The umbilical angle appears to show considerable variation, and I have measured angles ranging from 145 to 155 degrees.

The upper lip is slightly prosocline, making an angle of 80 to 85 degrees with a tangent to the whorl at the suture and bending slightly opisthocline near the carina. The outer lip is prosocline from the upper angulation (carina) and continues prosocline, deviating 7 to 10 degrees from vertical

across the outer whorl face. The lower lip is prosodine across the bourrelet and base, curves slightly forward midway between the bourrelet and the suture, and then straightens somewhat in its course into the umbilicus.

Discussion: Many shells of *Amphiscapha elli* are poorly preserved, and the matrix is tightly adherent, requiring hours of preparation with the needle for complete removal. Measurements of such prepared specimens, however, are at best only approximations, for the majority of these shells have suffered damage through compression after burial. Yochelson (1956) has warned against interpretations of such shells based only on surface appearance, and I concur heartily with his remarks. I have found whorl profile the most reliable means of differentiating the Conemaugh species of *Amphiscapha*, but to determine the profile with any assurance requires polished or thin sections. My description is based mainly on study of such sections.

All of my type specimens show damage to some extent, and particularly in the area near the aperture, where the shell wall was thin and susceptible to mashing. Nevertheless, these shells were selected because they had attained full growth and best illustrated most of the characteristics of the species. The two polished sections (Fig. 1, M and N) however, exhibit the profiles of undamaged whorls, and were obtained only after rejection of many specimens that displayed mashing or fracture after sectioning.

In the Conemaugh formation the subgenus *Amphiscapha* appears to be represented by two divergent groups of species. One of these lines is best typified by *Amphiscapha catilloides* (Conrad) from the Brush Creek member. Mature whorls of this species show definite upper and lower carinae, but the outer walls are not flattened in profile; Conrad (1842, p. 273) described this region as "obtusely carinated in the middle." These shells also bear a basal bourrelet, indicated in Conrad's figure of the type (1842, plate 15, fig. 3). It is to Conrad's species that *Amphiscapha elli* shows closest resemblance, differing mainly in its smaller size, more obtuse outer whorl face, and lesser development of carinae. Like *Amphiscapha catilloides* (Conrad) the form from the Carnahan Run member possesses a well-defined basal bourrelet. In most respects the Conrad species shows greater specialization despite its occurrence at a lower horizon in the Conemaugh than that from which *Amphiscapha elli* is derived. Related species, such as *Amphiscapha subrugosa* (Meek and Worthen) and *Amphiscapha muricata* (Knight) similarly outstrip the two Conemaugh forms.

A second line representative of the subgenus *Amphiscapha*, characterized by the Desmoinesian species *Amphiscapha reedsi* (Knight), also occurs in the Conemaugh. In comparison with *Amphiscapha catilloides* (Conrad) and *Amphiscapha elli*, the Knight species shows (1) an outer whorl face that is relatively flat, rather than rounded in profile, (2) a basal whorl face that tends to be convex, rather than flattened or somewhat concave, and (3) a basal bourrelet that is weakly developed or entirely lacking. Specimens in my collection from the Cambridge member near New Concord, Ohio, compare well with shells of *Amphiscapha reedsi* (Knight) from the Desmoinesian.

My collections indicate the presence of an undescribed species of *Amphiscapha* in the Ames member, and possibly another undescribed form in the Cambridge. It is planned to treat of these in a subsequent paper dealing with Conemaugh species of *Amphiscapha* in general.

Measurements of *Amphiscapha* (*Amphiscapha*) *elleri*

	Holotype (28728)*	Paratype (28729)	Paratype (28730)	Paratype (28731)
Height	2.7 mm.	2.8 mm.	2.8 mm.	2.8 mm.
Width	9.6 mm.	9.1 mm.	9.7 mm.	9.5 mm.

* Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective specimens.

Explanation of Fig. 1.

Approximate enlargements: A-L, 3 times natural size. M and N, 6 times natural size.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective specimens.

All specimens from the Carnahan Run member, Conemaugh formation, Pennsylvanian, at Gosser Hill, near Leechburg, Pa.

Fig. 1. *Amphiscapha* (*Amphiscapha*) *elleri* sp. nov.

- A,B,C. Top, oblique top and umbilical views of the holotype (28728)
- D,E,F. Top, oblique top and umbilical views of the smallest paratype (28729)
- G,H,I. Top, oblique top and umbilical views of the largest paratype (28730)
- J,K,L. Top, oblique top and umbilical views of another paratype (28731). Attached tube of *Serpulopsis* sp. showing in umbilical view.
- M. Polished section of a referred mature specimen (28732). Reflected light.
- N. Polished section of a referred specimen at an advanced stage of growth (28733). Reflected light.

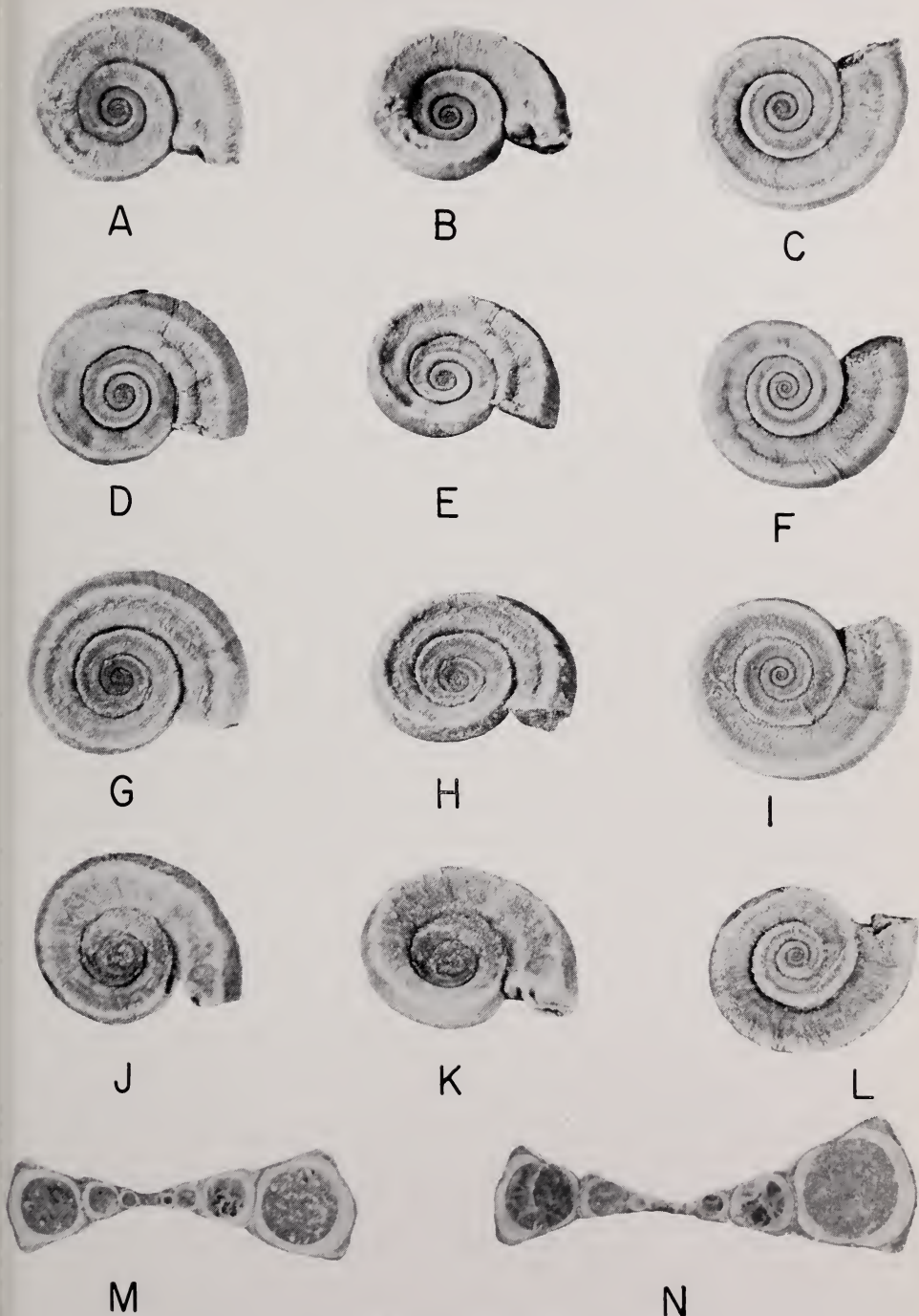


Fig. 1. *Amphiscapha (Amphiscapha) elleri* sp. nov.

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ART. 11. NOTES ON SOME BIRDS FROM CUBA AND THE ISLE OF PINES

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At the time that Todd published his important paper on the birds of the Isle of Pines (1916), Carnegie Museum had no bird specimens from the mainland of Cuba, and Todd was forced to rely on borrowed comparative material, often of limited extent. This lack was not remedied until relatively recently, when Carnegie Museum received as part of an exchange with the Cleveland Museum of Natural History a small but useful collection of Cuban birds made in 1941 by W. H. Corning, R. J. Kula, and P. N. Moulthrop. In the course of cataloguing and arranging this collection, comparisons of Cuban and Isle of Pines series of several species revealed variations not fully in accordance with current literature. The Carnegie Museum material of three such species was therefore supplemented by the excellent specimens collected by George E. Watson, 3rd, now in the Peabody Museum of Natural History, Yale University (Ripley and Watson, 1956). After the present paper was essentially completed, additional material of *Amazona leucocephala* and *Tyrannus caudifasciatus* was examined at the American Museum of Natural History, New York. I am indebted to Dr. Dean Amadon of the latter institution, and to Mr. Watson and Dr. Philip S. Humphrey of the Peabody Museum, for the use of their respective specimens.

Amazona leucocephala

Todd's description (1916, p. 228-229) of the Isle of Pines subspecies *palmarum* lists the 24 specimens then on hand from that island, but does not mention the extent of his comparative material from Cuba. Todd's manuscript notes reveal that he had but four Cuban specimens, all from the Museum of Comparative Zoölogy. After the rejection of *palmarum* by Peters (1928, p. 342), Todd's notes indicate that he examined seven additional Cuban specimens and was then inclined to follow Peters in synonymizing *palmarum* with *leucocephala*.

Barbour (1923, p. 82) showed that parrots from western Cuba were indistinguishable from Isle of Pines *palmarum*, a pattern of geographic variation known in several other species as pointed out by Todd (1916, p. 162). Although Barbour stated that "the living bird . . . which was the basis of Linné's description" probably came from Havana, he inferentially restricted the type locality of *leucocephala* to eastern Cuba, a restriction accepted by Peters (1928, p. 342, and 1937, p. 217). However, a most unfortunate *lapsus* in Peters's 1928 paper gives the citation from Barbour as claiming that specimens from eastern and central Cuba are identical with those of the Isle of Pines. This, of course, would (if true) negate any correlation between color and geography in *Amazona leucocephala*.

Comparison of a total of 26 Isle of Pines specimens with 13 from the mainland of Cuba indicates that Barbour was essentially correct in his division of *Amazona leucocephala*, except that I would place birds from central Cuba (Las Villas eastward) with the nominate race. Two specimens from Pinar del Rio (Peabody Museum) closely resemble the Isle of Pines series except that the abdominal patch is slightly paler. Of the remaining Cuban specimens,

two from Guantánamo approach *palmarum* in the extent of the abdominal patch, but the two series would certainly be considered separable by most current subspecific standards. The size and depth of color of the abdominal patch (larger and darker in *palmarum*) is the best character; the deeper throat color attributed by Todd to *palmarum* seems also to be valid but difficult to assess in worn birds. The darker green supposedly typical of Isle of Pines birds is only an average character; the darkest green individuals are *palmarum* and the palest *leucocephala*, but there is more overlap than in the other characters mentioned. In summary, I advocate the reinstatement of *Amazona leucocephala palmarum* Todd for the birds of western Cuba and the Isle of Pines.

SPECIMENS EXAMINED. *A. l. leucocephala*: Oriente, 6; Las Villas, 4; "Cuba", 1. *A. l. palmarum*: Isle of Pines, 26; Pinar del Rio, 2.

Glaucidium siju

Study of our series of 15 specimens from the Isle of Pines and four from Cuba had already suggested to me that the Isle of Pines race *vittatum* Ridgway was worthy of reinstatement when I found that Ripley and Watson (1956, p. 4) had come to the same conclusion based on their series of eight and seven respectively. In addition to the characters mentioned by Ridgway (1914, p. 805-806), it may be noted that the under tail coverts of nominate *siju* are immaculate white or nearly so, whereas those of *vittatum* bear distinct longitudinal streaks. Bond (1957, p. 12) has accepted the findings of Ripley and Watson on the validity of *G. s. vittatum*.

Gymnoglaux lawrencii

Our series consists of the two Isle of Pines specimens mentioned by Todd (1916, p. 234) plus two from Oriente and one from Las Villas. On the basis of this small series I would have had no hesitation in upholding the validity of Bangs's race *exsul*, as the two Isle of Pines specimens are strikingly less rufescent and more heavily spotted with white on the dorsum. I defer, however, to the superior series available to Ripley and Watson (1956, p. 4). Bond (1957, p. 12) has also accepted the findings of the latter authors with regard to the present species, and synonymizes *exsul* and *lawrencii*.

Tyrannus caudifasciatus

I tentatively follow those recent authors who have merged "*Tolmarchus*" with *Tyrannus*, although there are several qualitative differences which set the species *caudifasciatus* apart from other members of *Tyrannus*. In addition to those characters usually cited (see Meise, 1949, p. 71-75), the color pattern exhibited by the rufescent extreme, *T. c. gabbi* of Hispaniola, is without counterpart in other species of *Tyrannus* examined.

A rather frequent phenomenon in the avifauna of the West Indies is the existence of a series of geographically replacing populations so distinct from one another that they were not only originally described as full species (as, of course, were many other forms now ranked as subspecies), but would still be so considered by a more conservative school of taxonomy than now dominates the literature. In some groups it is possible to combine populations showing certain attributes in common into rather arbitrary "species", although all populations are allopatric; Bond (1956, p. 166, footnote) has suggested this

treatment for the tanager genus *Spindalis*, on the basis of coloration of females. It may prove convenient so to subdivide *Tyrannus caudifasciatus*, as it is difficult or impossible within the present system of trinomial nomenclature to consider all of the allopatric populations conspecific and yet indicate the obvious fact that some of these populations are more closely related to one another than to the rest. One possibility would be to restrict the specific name *caudifasciatus* to those forms with patterned rectrices, and unite under the name *T. taylori* the forms (*taylori* and *gabbii*) with rectrices unpatterned. Differences between island populations of these two species would then more closely approximate differences between continental populations currently recognized as subspecies. The population of *Tyrannus caudifasciatus* on the Isle of Pines, for instance, is clearly derived from the Cuban race, and differs from the latter at quite a different level from that of the Hispaniolan population. Although the differences between Cuban and Isle of Pines birds are not striking, they are nevertheless consistent and worthy of recognition at the conventional subspecific level, as follows:

Tyrannus caudifasciatus flavescens, subsp. nov.

Type: Carnegie Museum no. 39646, adult male; Los Indios, Isle of Pines; collected October 16, 1912, by G. A. Link, Sr. (original no. 191).

Characters: Similar to *T. c. caudifasciatus* of the mainland of Cuba, but under tail coverts, under wing coverts, and axillars strongly washed with yellow; light area at base of tail averaging more yellow. In very fresh plumage, the gray of the dorsum has a more greenish wash than in *caudifasciatus*, but this is quickly lost by wear. Todd (1916, p. 249) has rightly emphasized the color changes that wear and fading bring about; in worn Isle of Pines specimens the color of the under tail coverts may fade nearly or wholly to white, but the yellow underwing area is usually diagnostic in such birds. The increased yellow of *flavescens* is an approach to the condition of *bahamensis*, but Isle of Pines birds lack the yellowish flanks of that race. In wing length there is only a minute average difference, but the large extremes are Cuban specimens (♂ 112 mm. vs. 110 for Isle of Pines specimens; ♀ 108 vs. 105). Tail length appears to be somewhat more significant. In 15 Cuban males, tail length ranges from 85 to 93 mm., while 11 Isle of Pines males range from 83 to 89 mm., with one exceptional specimen measuring 94 mm. Figures for tail length of females: Cuba (8): 83-91; Isle of Pines (6): 81-87.

Range: Isle of Pines, Greater Antilles. No geographic variation was noted within the Cuban series examined.

SPECIMENS EXAMINED: *T. c. caudifasciatus*: Cuba various localities, 46.

T. c. flavescens: Isle of Pines, various localities, 18.

Mimocichla plumbea

This species exhibits an interesting geographic pattern of variation in Cuba and the Isle of Pines which may be considered as incipient subspeciation. Todd (1916, p. 254) commented on the variation in color of underparts of our Isle of Pines series, but made no comparisons with Cuban specimens. Examination of the combined Carnegie and Peabody Museum series indicates there is a decided tendency for Isle of Pines birds to have a paler rufous abdominal patch, often restricted in extent; also, the light area on the inner web of the primaries averages paler, more sharply contrasting, and broader in

Isle of Pines specimens, when compared with specimens of *M. p. rubripes* from central and western Cuba. Curiously, intermediacy in color of underparts is uncommon; when Cuban and Isle of Pines series are laid out, certain specimens immediately stand out as being the "wrong" color for their locality. Because of this phenomenon, too many specimens would be unidentifiable without verification of label locality to warrant subspecific separation of the Isle of Pines birds from *rubripes*, but the trend toward differentiation seems to be worthy of mention.

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ART. 12. AFRICAN PLATYSTOMATIDAE AND PYRGOTIDAE (DIPTERA), IN THE CARNEGIE MUSEUM COLLECTIONS

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Ninety-four specimens of Platystomatidae, mostly collected in the Cameroons from 1911 to 1935 by A. I. Good, as well as one Pyrgotid, are here reported upon. Several interesting species are included, two Platystomatidae (*Federleyella paucifenestrata* and *Plagiostenopterina goodi*) and the Pyrgotid (*Diasteneura similis*) being described as new species. Little work has been done on the African species of these groups since the great pioneer work of Hendel in 1914 and many of the present records are preceded only by the types. This is a part of a project to revise the Platystomatidae of non-palaearctic Africa.

Family PLATYSTOMATIDAE Subfamily PLASTOTEPHRITINAE

Conopariella acutigena Enderlein, 1922, Stettiner Entomologische Zeitung, v. 83, p. 12. 1, Lolodorf, Cameroons, Nov. 20, 1914 (A. I. Good). Previously known only from the types from Spanish Guinea and "Neu-Kamerun."

C. pallidipes (Enderlein, 1922, Stettiner Entomologische Zeitung, v. 83, p. 15 (*Anaphalantias*); Frey, 1932, Annals and magazine of natural history, (ser. 10), v. 9, p. 261. 1, Lolodorf, Cameroons, Dec. 10, 1914 (A. I. Good). Previously known only from the type from Spanish Guinea.

C. picipennis (Enderlein, 1922, Stettiner Entomologische Zeitung, v. 83, p. 14 (*Anaphalantias*); Frey, 1932, Annals and magazine of natural history, (ser. 10), v. 9, p. 261. 1, Efulen, Cameroons, May 5, 1917 (H. L. Weber); 1 each, Lolodorf, Cameroons, March 6, 1911, Nov. 7, 1914 (A. I. Good). Previously known only from the type series from Cameroons and Spanish Guinea.

Federleyella paucifenestrata, sp. nov. (Fig. 3). 1, Lolodorf, Cameroons, Dec. 10, 1914 (A. I. Good), *holotype*.

Male. Length of wing, 4.3 mm. Head with lower occiput and genae considerably widened, 1.8 mm. wide at lower edge. Color largely yellow, upper half of anterior aspect of expanded genae and ocellar triangle black. Thorax black above, yellow below; most of mesopleura and pteropleura dark brown; humeri yellow. Legs yellow, apical one-fourth of middle and hind femora and all tibiae black. Wings as in Fig. 3, dark brown with hyaline spots, none of which are distad of *ta*. Squamae and their cilia blackish. Halteres yellow. Abdomen yellow below and basidorsally, apex of second segment and remainder of dorsum black, with rather long black hairs.

This species may be separated from the only other known species of *Federleyella* as follows:

- 1 (2). Wing with two hyaline spots closely distad of *ta*; fore tibiae yellow; male head not broadened below.....*F. septemfenestrata* (Enderlein)
- 2 (1). Wing wholly dark brown distad of *ta*; fore tibiae black; male head broadened below.....*F. paucifenestrata*, sp. nov.

Both species have the fourth wing vein from *ta* to a little beyond *tp* with longish setae on the under side.

F. septemfenestrata (Enderlein), 1922, Stettiner Entomologische Zeitung, v. 83, p. 15 (*Anaphalantias*); Frey, 1932, Annals and magazine of natural history, (ser. 10), v. 9, p. 263. Lolodorf, Cameroons, 1 each, July 8, 1920, July 16, 1924 (A. I. Good). The specimens are topotypical—the only other record is of the unique type, also from Lolodorf.

Oeciotypa parallelomma Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 281; Speiser, 1919, Deutsche Entomologische Zeitschrift, 1915, p. 99. Lolodorf, Cameroons, 1 each, March 8, 1911, Feb. 28, 1921 (A. I. Good). The type was from Ashanti (Ghana) and Speiser recorded the species from the Cameroons.

Onceroparia strigata Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 100. Batanga, Cameroons, 1 each, Aug. 30 and Nov. 13, 1911; 1, Metet, Cameroons, Nov. 16, 1918 (all A. I. Good). Previously known only from the type series from Spanish Guinea and Cameroons.

Subfamily PLATYSTOMATINAE

Bromophila caffra Macquart, 1846, Diptères exotiques, suppl. 1, p. 217. 1, Mt. Selinda, S. Rhodesia. Widespread in eastern and southern Africa.

Clitodoca fenestralis Macquart, 1843, Diptères exotiques, v. 2, pt. 3, p. 204. 16, Cameroons (Batanga; Ebolowa; Efufup; Efulen; Lolodorf, Metet); Gabon (Kangwé, Ogové R.). Known from several localities along the coast of the Gulf of Guinea.

Coelocephala stigma Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 273; Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 129. 1, Freetown, Sierra Leone. Known from Uganda, Nyasaland, Cameroons, N. Nigeria, and Togo. The present record is therefore a western extension.

Elassogaster inflexus (Fabricius), 1805, Systema Antliatorum, p. 273 (*Dacus*). 1, Freetown, Sierra Leone. Known from several localities along the Guinea coast.

E. niger (Van der Wulp), 1884, Comptes Rendus de la Société Entomologique de Belgique, v. 28, p. 295 (*Epicausta*); *E. vanderwulpi* Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 2, p. 83, *new synonym*. 3, Cameroons (Lolodorf; Batanga). Widespread from the Guinea coast to Aden and South Africa. Hendel's species is no more than a phenotypical variety.

Engistoneura obscura Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 365; Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 139. 3, Dakar, Senegal; 1, Metet, Cameroons. The types were from Kribi, Cameroons, and Buea, Nigeria. Enderlein recorded the species from Spanish Guinea and named several varieties from the same area.

Euthyplatystoma seriatopunctatum (Enderlein), 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 135, *new combination* from *Lulodes*; *E. nitidum* Frey, and var. *tibiale* Frey, 1932, Annals and magazine of natural history, (ser. 10), v. 9, p. 253, *new synonym*. 1, Lolodorf, Cameroons, Jan. 23, 1925 (A. I. Good). I have examined male post-abdomens of several specimens of an extensive series from the Congo. The examination revealed that Frey's variety is no more than phenotypical and adduced the synonymy. The type

of *Lulodes seriatopunctata* was from the Gold Coast, that of *Euthyplatystoma nitidum* from Uganda, and that of var. *tibiale* from the Gold Coast.

Lophoplatystoma hirsutum Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 396. 1, Lolodorf, Cameroons, Jan. 29, 1916 (A. I. Good). Previously known only from the type from "Kamerun."

L. leucolena Speiser, 1914, Deutsche entomologische Zeitschrift, 1914, p. 13. 2, Metet, Cameroons, Nov. 16 and Dec. 14, 1918 (A. I. Good). Known from the Cameroons, Nigeria and Spanish Guinea.

Lule stellata Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 99. 4, Cameroons (Batanga; Lolodorf). The type series was from Cameroons, Togo, and Spanish Guinea.

Naupoda camerunensis Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 31. 1, Lolodorf, Cameroons. Previously known only from the type series, also from the Cameroons (Lolodorf and Johann Albrechtshöhe).

N. puella Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 301. 1, Metet, Cameroons, March 15, 1919 (A. I. Good). Previously known only from the holotype from Obuasi, Ashanti.

Paryphodes tigrinus (Enderlein), 1912, Zoologische Jahrbücher, Abteilung für Systematik, Geographie und Biologie der Tiere, v. 33, p. 374 (*Simomesia*); Speiser, 1913, Deutsche entomologische Zeitschrift, 1913, p. 144; Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 256; Bezzi, 1914, Bollettino del Laboratorio di Zoologia Generale e Agraria, Portici, v. 8, p. 298; Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 122. 2, Lagos, Nigeria; 1, Batanga, Cameroons. Known previously from several localities along the Guinea coast.

Peltacanthina cervina Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 380. 14, Cameroons (Batanga; Metet). The specimens are evenly divided between forms with dark brown to blackish thoracic dorsum, as in Hendel's description, and those with entirely yellowish thorax, but they are otherwise identical. Hendel's type series was from the Cameroons and Natal.

P. lurida Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 149. 1, Metet, Cameroons, Nov. 16, 1918; 1 each, Lolodorf, Cameroons, March 4, 1911, and Jan. 23, 1925 (all A. I. Good). Enderlein's description is scanty, but the form is quite distinct and I have no hesitation in referring these specimens to *P. lurida*. The types were from Spanish Guinea.

P. octodecim (Speiser) 1911, Nassauischer Verein für Naturkunde, Wiesbaden, Jahrbuch, v. 64, p. 254 (*Engistoneura*); Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 390; Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 147. 1, Lolodorf, Cameroons. Known from West Africa and the Cameroons.

Plagiostenopterina goodi, sp. nov. (Fig. 1, 2). 1, Lolodorf, Cameroons, Sept. 24, 1913 (A. I. Good), *holotype*.

Male. Length of wing, 4.9 mm. Color dark metallic greenish black, except brown first two and basal part of third antennal segments, fore femora and apical half of fore coxae. Halteres pale yellow; squamae yellowish with yellowish cilia, blackish at fold.

Head with front parallel-sided, 0.33 of head-width, subshining, including orbits, with sparse and shallow pits anteriorly, and with whitish hairs except on roundish spot in central one-third, which is dull black with black hairs. Cheeks and parafacials very narrow. Palpi black, a little brownish at tip, with black bristles. Arista without palette, practically bare. Chaetotaxy: 1 cruciate *uti*, 1 *vte*, 1 *occ* above middle of head, 2 *genal* (1 a little posterior to lower edge of eye and 1 midway between the first and the neck, near oral margin).

Thorax with dorsum and mesopleura strongly roughened, with white pile except on mid-dorsum and on pteropleura, the longish hairs of which are all black. A pair of weakly pruinose gray lines extends down the middle of the thorax and some grayish pruinosity lies near lateral margins. Prosternum broad, with rather short and numerous pale hairs. Scutellum with moderately long black hairs dorsally. Chaetotaxy: 1 *h*, 2 *ntpl*, 1 *sa*, 2 *pa*, 1 *dc*, 2 *sc*, 1 *mspl*.

Middle femora strongly constricted dorsoventrally in apical fourth above; fore femora without strong hairs, bristles, or papillae below; hind basitarsi wholly covered with whitish hairs.

Wings as in Fig. 1, hyaline with brown costal margin from end of *Sc* to tip of third vein; first basal cell yellow, becoming brown at *ta*; base of first posterior cell brown obliquely from *ta* to *tp*; a large light brown area in apical half of discal and third posterior cells.

Abdomen shining, slightly roughened, with decumbent white hairs over most of surface, some erect white ones basally and some erect black ones near segmental margins. Andrium as in Fig. 3, aedeagus with apical pair of processes only slightly longer than the sausage-shaped glans.

The nearest relative to *P. goodi* is apparently *P. submetallica* Loew, which also has yellow halteres, but differs most obviously in having a spindle-shaped arisal palette (in male); only small brown central wing spot about *tp*; front reddish brown without dull black spot, but with narrow white-pruinose orbits; and hind basitarsi with black hair anterodorsally.

P. submetallica (Loew), 1852, K. Preussische Akademie der Wissenschaften, Berlin, Sitzungsberichte, 1852, p. 600 (*Stenopterina*); Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 58; Enderlein, 1924, Mitteilungen aus dem Zoologischen Museum in Berlin, v. 11, p. 106; Malloch, 1931, Proceedings of the United States National Museum, v. 78, art. 15, p. 16. 2, Cameroons (Batanga; Lolodorf). Known from many localities in central and southern Africa.

P. vicaria Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 409. 1, Batanga, Cameroons, Aug. 7, 1913; 1 each, Lolodorf, Cameroons, Nov. 17, 1913, May 14 and 15, 1914 (all A. I. Good). Previously known only from the holotype from Uganda.

Pseudoscholastes marshalli Frey, 1932, Annals and magazine of natural history, (ser. 10), v. 9, p. 251. 1, Fulasi, Cameroons, Dec., 1913; 1 each, Lolodorf, Cameroons, Nov. 17, 1913, Nov. 16, 1914, Nov. 13, 1920 (all A. I. Good). Previously known only from the holotype from Sierra Leone.

Rivellia neotera Speiser, 1915, Deutsche entomologische Zeitschrift, 1915, p. 98. 1, Batanga, Cameroons, Feb. 20, 1911 (A. I. Good). Previously known only from the types from Duala, Cameroons.

R. parallela Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 169. 4, Batanga, Cameroons (A. I. Good); 5, Lagos, Nigeria. Previously known only from the holotype from Viktoria, Cameroons.

R. rectangula Hendel, 1914, Abhandlungen der Zoologisch-Botanischen Gesellschaft in Wien, v. 8, p. 168. 2, Freetown, Sierra Leone, July 10, 1936. Previously known only from the holotype from Forcados, Nigeria.

Family PYRGOTIDAE

Diasteneura similis, sp. nov. 1, "Congo," (C. B. Antispel), *holotype*.

Male. Length of wing, 6 mm. Very much like *D. variceps* Curran, differing as follows: Cheeks 0.55 as wide as eye-height; antennae yellow, third segment brown apically, back of head with inverted T-shaped yellow mark above neck; scutellum wholly yellow; tarsi wholly yellowish; wings hyaline in basal two-thirds, dark brown in apical one-third, in fork of radial sector, in marginal cell from fork of radial sector to end of pterostigma, and in pterostigma and costal cell; discal cell and first basal cell wholly hyaline.

The known species of *Diasteneura* Hendel may be separated as follows:

- 1 (2). Broad hyaline mark on wing extending forward from apical one-third of discal cell not surpassing fourth vein; all abdominal tergites partly or wholly reddish; cheeks nearly as wide as eye-height (male, South Africa; 1908, Wiener entomologische Zeitung, v. 27, p. 150; type of genus).....*D. laticeps* Hendel.
- 2 (1). Hyaline band extending to costa, base of wing largely hyaline; first to fourth abdominal tergites wholly black; cheeks not more than 0.75 as wide as eye-height.
- 3 (4). Cheeks 0.75 as wide as eye-height; first and second antennal segments black; discal cell partly brown basally; scutellum black laterally (female, Stanleyville, Congo; 1928, Bulletin of the American Museum of Natural History, v. 57, p. 343).....*D. variceps* Curran.
- 4 (3). Cheeks a little over half as wide as eye-height; first and second antennal segments yellow; discal cell wholly hyaline; scutellum wholly yellow*D. similis*, sp. nov.

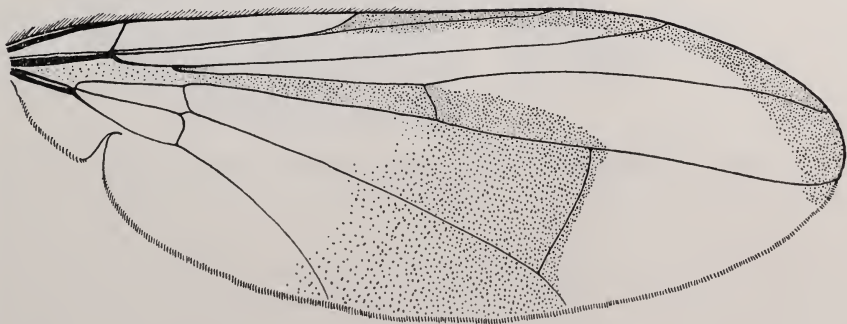


Fig. 1. *Plagiostenopternia goodi*, sp. nov., wing of holotype



Fig. 2. *Plagiostenoptera goodi*, andrium in lateral view



Fig. 3. *Federleyella paucifenstrata*, sp. nov., wing of holotype

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ART. 13. A PROPOSED RECONSTRUCTION OF THE JAW
MUSCULATURE OF DIPLODOCUS

BY GEORGE HAAS

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An attempt to reconstruct the muscles of an extinct vertebrate is, of course, only guesswork, but, in spite of this fact, the preserved parts reduce the unlimited possibilities of such a reconstruction to a few alternatives only. In the case of a reconstruction of the cranial muscles of a fossil reptile belonging to the archosaur group, we may get some guidance from conditions found in recent representatives of this group, namely from crocodiles and birds. The only other type of recent reptile exhibiting two temporal arches, *Sphenodon* (*Hatteria*), is of rather doubtful value, but must be taken into consideration. On the other hand, a skull of such remarkable peculiarities and proportions as that of *Diplodocus* imposes in itself certain limitations of a reconstruction of muscles out of sheer phantasy. The relative positions of the orbit, the temporal arches, the endocranium, and the shape and inclination of the quadrate towards the lower jaw forces the investigator into a restricted area of several possibilities. One of those may offer the best approach to the real conditions enforced and caused by a very strange configuration of the skull. Many structures, like foramina for nerves or blood vessels, muscular scars, and the spatial compatibility of bulkier structures like muscles give, in many cases, a fairly accurate guide to reasonable guesses.

The skull of *Diplodocus* has a series of peculiarities which have a profound influence on the general arrangement of the jaw muscles, especially the adductors of the mandible.

The shifting of the fused nasal apertures to the top of the skull is accompanied by a strange elongation of the preorbital, and a very considerable shortening of the temporal, areas. The orbits have a very high position and are of spectacular size. The slanting position of an elongated quadrate brings the articulation of the lower jaw under the middle of the antero-posterior orbital diameter, whereas the small superior temporal opening remains in a fairly "normal" position, dorso-posteriorly of the orbit. The lower fenestra is brought into an oblique position. The antero-ventral end surpasses the anterior margin of the orbit by \pm the same distance by which the postero-dorsal end of the fossa projects behind the posterior border of the orbit. The fossa is of a very considerable depth, bordered posteriorly by the slanting external ridge of the quadrate, which projects rostro-medially into the temporal opening, mostly by the aid of the pterygoidal wing of this bone. The whole lower temporal window, together with the upper one, were, of course, the main places where the adductors could develop. As in birds, therefore, a good deal of the adductor mass had (according to the position of the lower temporal opening) a suborbital position. This similarity, however, should not be overemphasized. The quadrate in birds has a streptostylic dorsal joint and is a short and essentially vertically directed bone, and clearly delimited temporal fossae (in a normal reptile-like form) do not occur. As in birds, the post-temporal opening, usually totally absent in birds, is, here too, reduced.

The peculiar position of the articulation for the mandible precludes a mechanically feasible transfer of the pull of the adductor muscles to the lower

jaw. This may be inferred from the lack of significant muscular ridges on the external surface of the mandible, and from the shape and crowded disposition of the teeth on the cranial tips of both jaws, and the lack of any teeth on the palate. The whole, vertically deepened osseous lamina formed by the maxillary, jugal and quadratojugal, when the mouth is shut, closely overlaps the vertical wall of the mandible. Especially the medial surface of the lower temporal arch (much shortened by the elimination of the jugal) shows no indication of any muscular origins from the inside of this bar (as in birds). The peculiar dentition shows no traces of any wear in either specimen seen by the author. We shall, later, propose a new theory about the food and feeding of these animals which seems preferable to the prevalent idea of a floating vegetable food (algae).

The skull as a whole is of a very delicate structure; the contact of the neurocranium with the roof of the mouth (palatopterygoid series) maintained by very slender basipterygoid processes seems to imply a streptostylic condition of some kind. This impression is even enhanced by an investigation of the skull kept in the collection of the American Museum of Natural History (969), where the upper end of the quadrate seems to form a bird-like articulation with the skull proper! The reconstruction of this skull has, however, been criticised by Holland (1906). The much better preserved and prepared specimen in the Carnegie Museum (C.M. 11161) shows a fixed attachment of the quadrate against the squamosal, the postfrontal, and postorbital, above; a long, ventrolateral smooth suture with the quadratojugal, and, still more important, a serrated, rigid, suture with the caudal end of the pterygoid (at the medial ventral surface of the "wing" of the quadrate).

A kineticism was, therefore, impossible in the sense of a mutual movement of cranial areas by aid of any articulations or flexible sutures. But as in the "akinetik" *Sphenodon*, a weak constrictor internus dorsalis musculature did exist, perhaps in order to stiffen elastic bony bars, in certain areas, perhaps simply as a remnant dating back from earlier kinetic stages.

Adductores externi.

We have had to exclude the possibility of the existence of a muscle rising from the lower temporal arch, owing to the lack of any scar of muscle origins at its flattened medial wall. The lower contour of this arch considerably overlaps the dorsal contour of the lower jaw when the mouth is closed. We are here, doubtless, in the region of the rictus oris, where the vertically elevated base of the lower arch fulfills the task of the external rictal plate in a recent saurian. The internal rictal plate was (as we shall see later), slightly more rostral in position, owing to cranially protruding muscles at the inside of the smooth coronoid prominence.

1. *Adductor mandibulae externus superficialis.* Fig. 1.

In a sharp contrast with the blade-like transverse section across the lower temporal arch, the suborbital bridge, formed by the jugal and postorbital, has a transversely broad base, which is deeply hollowed out by a longitudinal groove. This area certainly formed the elongated origin of the external adductor portion (*adductor medialis externus superficialis*: 1 in Luther-Lakjer's abbreviations). This muscle probably lost its thickness in ventral direction and dwindled down to a very thin muscular or only tendinous sheet at the level of the lower temporal arch. Certainly it inserted at the lateral surface

of the lower jaw, between the posterior slope of the coronoid prominence and the articular area. This muscle is probably the only one which inserted at the lateral surface of the mandible or at its dorsal margin. The very close fitting, almost shearing lower margin of the maxilla (ventrally of the pre-orbital aperture) leaves little room for an intervening muscular sheet, and a very shallow external insertional scar only is discernible at the external face of the mandible. A tendinous or a fleshy lateral insertion, very flattened along the dorsal ridge of the mandible are the only acceptable alternatives for the insertion (or a combination of both conditions could have taken place).

The muscle, whatever its insertion may have been, was a retracting adductor, filling the whole lower temporal fossa as an external layer, as in comparable cases in recent reptiles. Its posterior slope along the lateral ridge of the quadrate was probably connected with this bone by a tendinous layer. Externally, the thin muscle was probably covered by an insertional aponeurosis which reached the lateral surface of the mandible. Perhaps this lateral cover was partially backed at the medial surface by muscular fibers which reached up to the summit ridge of the mandible; this possibility would form a kind of reasonable compromise between the alternatives mentioned above.

2. *Adductor mandibulae externus medialis*. Fig. 2-3.

Two different interpretations will be found in the following paragraph; one based on a simple, the second (and preferred) based on a bipartite *pseudotemporalis*. The figures are based on the second interpretation.

The reconstruction of the adductor medialis was much more difficult, owing to probably incorrect restorations in the New York skull. The Pittsburgh specimen offered a much better chance to get appropriate results. There is no doubt that the upper temporal fossa was filled mostly by the wide upper ends of the sloping portions of the *adductor mandibulae externus medialis* (2), and the *adductor mandibulae externus profundus* (3) and the *pseudotemporalis superior* if this muscle was present. All these muscles could certainly not have reached the mandible in a course *medially* of the strongly developed anterior flange of the quadrate; therefore a rather narrow space between this flange and the *adductor mandibulae externus superficialis* must have contained these narrowed muscles on their way across the lower temporal fossa towards the lower jaw (at its medial face). But, an extensive transversely directed osseous shelf (between the upper temporal fossa and the posterodorsal part of the orbit) narrows considerably (Fig. 7) the straight access of muscles from the upper to the lower temporal fossa. Therefore, a simple, straight course of, at least a part of the adductors descending from the upper window was impossible. It was thinkable only for muscles rising from the posterior (and transversely directed) frame of the fossa, where the squamosal is deeply hollowed out for the scar of muscle origin of straight-fibered muscles, which could not have filled more than about the posterior third of the upper temporal fossa. It may be assumed that this muscle was an *adductor mandibulae externus profundus* (3). But how could adductors rising from the anterior and medial part of the periphery of this opening have reached the lower fossa and the mandible, by-passing the quadrate flange at their inner (medial) surface?

One possibility, which had to be envisaged, was deduced from the muscular arrangement found in many birds, where *adductores externi* invade suborbital

areas in connection with the preorbital position of the rictal area. I think that the funnel-shaped fossa (especially the caudally sloping, deeply excavated anterior and lateral margins of the fossa) inhibit a substantial penetration of adductors rising from the margins of the fossa into the orbital area. I would rather believe that a part of the *medialis* started, cranially of the *profundus*, from the medial periphery of the fossa, and a separate belly from the cranio-lateral anterior circumference. In the Pittsburgh specimen a vertically descending osseous ridge (Fig. 7, caudal view) clearly delimits both areas. We would have, therefore, a bipartite, "double-headed" *medialis*, a portion 2a, rising from the antero-lateral margin of the fossa up to the vertical ridge, and a portion 2b which was probably covered anteriorly by the cranio-lateral belly of 2a. In the description of the occiput (Gilmore, 1932) C.M. 662 this vertical ridge is not distinguishable but the complete skull (C.M. 11161) shows it very clearly. This structure probably corresponds with the dorsal wing of the so-called alisphenoid (Holland).

The general direction of the rostroventrally sloping fibers of 2 and 3 is determined posteriorly by the surface of the upper part of the quadrate "wing", and, anteriorly, by the position of the coronoid elevation.

3. *Adductor mandibulae externus profundus*. Fig. 2-3.

The scar of muscle origin of the *adductor profundus* (3) was, most probably, at the posterolateral part of the upper temporal fossa. Three muscles, therefore, filled this approximately circular window: 2a (cranio-lateral) the rostralateral part; 2b the dorsomedial (probably largest) area, whereas 3a with straight and very slanting fibers, filled the latero-ventral part of the fossa (Fig. 3).

For alternative and preferable interpretations see below; the first one is based on a single, the second one on a bipartite *pseudotemporalis* muscle.

At least, one subdivision of the *adductor externus profundus* must be assumed; a deep belly, 3b,* which filled the small posttemporal fossa and crossed from caudodorsally into the deepest layers (the posteromedial ones) of 3a whose origin was limited to the posterolateral parts of the upper temporal fossa. Of course this part was very slender owing to the minuteness of the posttemporal window; its fibers started (as in saurians) from the lateral and dorsal margin of the opening, bending, in their way forwards, around the ventromedial periphery of this perforation (Fig. 7).

Medialis and *profundus* cross in their slanting descent to the mouth slightly towards the posteroventral corner of the large orbit in order to reach the insertional fields. An alternative interpretation of the same areas of origin, under the assumption of the existence of a bipartite *pseudotemporalis*, preferred to that given here, will be found below.

The inside of the mandible gives some information about the insertion of add. ext. 2 and 3, respectively, and other muscles. Four insertional areas may easily be distinguished at the inner surface; two caudal ones for the adductors rising from the quadrate and, near the posteroventral contour, the insertional groove for the *pterygoideus*. Two more rostrally situated muscle insertions consist in a deep groove inside the coronoid elevation, and below this deeply hollowed longitudinal area. Another, very clearly marked, muscular scar is very obvious.

*Not shown on illustration

Discussion of both V_3 foramina at the medial side of the mandible.

The main branch of the trigeminal 3 seems to enter the mandible at the bottom of the deep muscular trough medially of the "coronoid elevation." The posterior foramen, situated in the groove in front of the articulation of the jaw is much narrower than the more cranial one, and is probably the entrance foramen for the posterior cutaneous branch of V_3 . The exit of this foramen at the lateral surface of the articular could not be found with certainty, but the whole interpretation given here agrees better with conditions found in recent sauropsids than the other alternative, seeing in the posterior foramen the entrance of the main mandibular branch, and in the anterior one a deepened muscular impression only; but, in any case, the posterior foramen would indicate the level separating the *adductor posterior* from the *adductor externus* group.

There can not be any doubt that the anterior ventral scar is the insertional area of the deepest of the anterior adductor muscles (the *pseudotemporalis* complex). The anterior dorsal groove accommodated the three muscles descending from the upper temporal fossa: 3a and the deep belly as the innermost, probably inserting more ventrally, perhaps even forming an intra-mandibular prolongation into the deeply enlarged Meckelian fossa as in crocodiles, where, however, the *medialis* penetrates into this field. In succession from medial to lateral 2b and 2a, the *adductor externus medialis*, respectively, occupied more dorsal areas of the lateral wall of this deep Meckelian groove. It is impossible to get a detailed idea of the shape of the insertions of the four parts of both adductors involved; whether some of them inserted in the form of aponeurotic layers which collected the more dorsally situated fleshy parts, or directly. Probably the first way of insertion was followed by one or both parts of the *medialis*.

We must try to get an idea about the muscles sloping down from the anterior wing and the stem of the quadrate.

In the crocodilians, where the quadrate has a sloping which is just in the contrary direction to that of *Diplodocus* (the lower end posteriorly of the upper one), the whole *adductor externus profundus* rises from this bone. Here, in *Diplodocus*, the same muscle developed mostly from the upper temporal fossa. There is no doubt that the following muscles could have risen from the anterior area of the quadrate:

1. The *adductor posterior* as a whole; this muscle has always such an origin in sauropsids and constitutes the innermost and most caudal adductor.
2. Parts of the *pseudotemporalis* group.
3. Possibly parts of the deepest layers of the *adductor mandibulae externus profundus*.

Because the course of the trigeminus 3 can be only approximately guessed, a delimitation of muscular portions in relation to the trigeminal branches can not be given precisely, but, some skeletal facts observable in the configuration of the quadrate give at least a clue. The wing represents a surface appropriate for the origin of a possibly composite *adductor posterior*. This muscle probably covered the more external parts of the sloping quadrate from its upper (posterior) end onto the lower border of the wing. Since the trigeminus 3 had to cross the ala quadrati in an oblique way forwards, covering a considerable

distance in order to reach the mandible (at a short distance in front of the articulation) we can not decide whether this slanting, external part of the *adductor posterior* was not duplicated by a deep portion of an *adductor externus profundus* (3c) at its lateral surface. In other words, we could admit the possibility of an *adductor mandibulae externus* 3c rising from the same area, but laterally of the descending V_3 ; otherwise, only an *adductor posterior* alone should be inferred. In birds, such an *adductor* 3 *caudalis* is well known (*Cephus*, *Aprosmictus*, *Crypturus*, *Oedemia* and *Gallus*). The topographic relation between the entrance of the trigeminal foramen into the mandible and the pre-articular muscular groove in front of the jaw-joint speaks more in favor of the presence of a well developed extra-trigeminal muscle rising from the quadrate; and this could be only a 3c "caudalis." The more or less parallel *adductor posterior* reaches the lower jaw somewhat in front of the *adductor profundus*. Fig. 3 represents such a 3c, a muscle which probably was connected with 3a and the insertional aponeurosis of the *pseudotemporalis* group. But the presence of a deeper, short-fibered, caudal *adductor posterior* with steeply descending fibers is certain; the lower end of the quadrate widens in the area of articulation transversely and a deep hollow faces cranially just above this hinge, clearly set off from the wing portion. From this deep niche the triangular, caudal part of the *adductor posterior* (B) could enter the furrow behind the trigeminal foramen. In other words, I think that this caudal *adductor posterior* (B) was inserted laterally and caudally of the long-fibered portion A, (Fig. 5, *adductor posterior* A, B).

The pseudotemporalis. (Fig. 3-4).

It can easily be seen that the cranial tip of the quadrate wing is the most medial part of the bone as in birds. This inward-bent part released a *pseudotemporalis profundus*, which inserted in the lower of both anterior muscular insertion scars at the medial face of the coronoid elevation of the mandible. This deep insertion is fitting for the innermost anterior adductor. But we wonder whether this muscle was laterally duplicated by a pseudosuperior, as in most lizards, birds, and *Sphenodon* (not in the crocodiles). This muscle is strictly postorbital in birds and *Sphenodon*. At the first glance there is no possibility of locating any temporal adduct muscle which would have to be almost the innermost at the inside of the mandible, and which should be situated medially of the V_2 and originate from a postorbital area. This same muscle should have a deep but rather cranial position compared with the *adductores externi* 2 and 3.

There is only one area, the laterally bulging ventroposterior wall of the orbital bar, which forms at the caudal end a clear muscular scar. Obviously a temporal muscle, rising from this area would slightly penetrate into the ventroposterior area of the orbit, swing medially of the suborbital wall forwards, and follow the deeper slanting temporal muscles, covered by the sub-orbitally rising *adductor externus* 1. If this possibility should be accepted, this muscle, owing to its position laterally of the muscles rising from the upper temporal fossa, could not possibly be a *pseudotemporalis superior*, but rather a separate portion of the *adductor medialis*; but, in this case, the muscle, sloping from the dorsomedial circumference of the upper temporal fossa, would be a *pseudosuperior*, squeezed in ventrally between the more dorsally inserting adductors 2 and 3 and protruding (as an aponeurosis) into

the anteroventral insertional field, joined medially by the *pseudotemporalis profundus* (Fig. 2-4).

Such an explanation would give the clue for the peculiar postorbital buttress (Fig. 7-8) and would place the *pseudosuperior* in a "normal" position inside the upper temporal fenestra (cf. *Sphenodon*). Such a caudomedial position would well correspond to the position of the trigeminal foramen; the nerve, in its course to maxilla and mandible, could without a detour swing around the posterior margin of this muscle.

It would, however, be very strange to see a *pseudoprofundus* much more lateral than the *pseudosuperior*, but the insertions would be possible and in proper sequence; e.g. the terminal tendinous sheet of the *pseudosuperior* could collect at its inner surface the *pseudoprofundus* or the latter only inserted directly at the mandible. I prefer this interpretation to the other given above and I named the muscles involved in accordance with this only feasible position of the *pseudosuperior*. Fig. 2 shows that a double-headed *adductor mandibulae externus medialis* could have been formed by the deep posteroventral bone partition between the orbit and the upper temporal fossa. A portion 2a rising suborbitally would join the deeper portion 2b from the anteroventral corner of the fossa: both would, fused, duplicate laterally the adductor 3a and the deep belly (36).

Summary of the adductor arrangement.

Origins from upper temporal fossa:

anterolaterally 2b

posteriorly 3a

medially *pseudosuperior*

36 (deep belly)

from posttemporal fossa:

2a

from posterolateral corner of orbit:

1

from suborbital bar:

3c (laterally); post. A (ant.) and
post. B (post.); *pseudoprofundus*
(anterior wing)

from quadrate:

The pterygoideus muscle.

The posterolateral surface of the mandible shows no traces of a lateral insertion of a *pterygoideus*. The "Kauballen" probably did not exist and the moderately swollen posterior end of the bipartite muscle inserted along a ridge close and almost parallel to the posteroventral contour of the lower jaw. This ridge extends also into the retro-articular process and is well separated by its lower position from the muscular scar for the *pseudotemporalis* group. In the lateral view this muscle probably did not extend beyond the ventral contour of the lower jaw.

One part of the *pterygoideus* started from the area, where ectopterygoid and pterygoid meet, i.e. from a point near the anchorage of the palatal skeleton with the maxillary. The whole dorsomedially flattened muscle had a caudal slope of about 15° (m. ptg. dorsalis) and was perhaps slightly covered by the ventrolateral "bridge" to the maxillary from above. A separate, medio-dorsal portion of the *pterygoideus* could have existed, rising from the (medial) inner slope of the pterygoid in front of the *processus basipterygoideus*. This portion followed a more transverse course and probably inserted ventrally under the long-fibered *pterygoideus dorsalis* (from the maxillary bridge).

These two parts would be roughly comparable with Lakjer's *pterygoideus* A-B and *pterygoideus* C., respectively, in *Crocodylus*.

The long-fibered would be comparable with a *pterygoideus dorsalis*, the short-fibered (dorsal) would be comparable with a *pterygoideus ventralis* in birds.

Constrictores interni dorsales.

It has been remarked above that the skull of *Diplodocus* could hardly have been of a kinetic type but, as in *Sphenodon*, muscles which stiffened the link between the endocranium, the dermocranium and palatopterygoid complex, did exist. There are clear indications of the existence of a *protractor quadrati*, the specialised remnant of a *protractor pterygoidei*. Its traces consist in a concavity at the medial face of the ala quadrati which faces a muscular furrow at the posterior slope of the slender *processus basalis*.

The functional value of such an arrangement probably consists in establishing a stiffening pull of the quadrate towards the base of the endocranium. At the dorsomedial process of the pterygoid in front of the cavity for the basipterygoideal articulation a muscular scar faces another, anterior, muscle groove along the dorsolateral surface of the *processus basalis*. This was, most probably, an appropriate area for a retrahent thin muscle, roughly corresponding to the retractor and levator pterygoidei of different Sauropsida.

The lateral wall of the endocranium itself shows a number of muscular scars and ridges; but these structures are not traces of the jaw musculature. They form the origins of the muscles moving the eye and the eyelids (facing the orbit) or, posteriorly, of certain occipital muscles (facing caudally) and will not be analyzed here. It may be mentioned, however, that the antero-dorsal flap of the quadrate wing dismissed perhaps, in a dorsal direction, a *pseudotemporalis bulbi*, a muscle found in birds, but missing in crocodiles and *Sphenodon*.

Depressor mandibulae.

In several details the *depressor mandibulae* left its traces; the postarticular portion of the articular bone exhibits two muscular scars of very different size. The whole lateral face caudal of the jaw articulation is deeply concave as seen from above; a muscular insertion covered, most probably, as a long sheet the whole outside of the postglenoidal region, reaching down to the ventral contour of the *processus*.

Another scar, a very sharp excavation, pointing in a posterodorsal direction, is situated at the very end of the lower jaw. We may, therefore, infer the presence of a double *depressor mandibulae* muscle:

1. A lateral, ventrally fan-shaped expanded portion, rising from the upper end of the quadrate (the most caudal area of this bone) and ending at the lateral insertional scar on the retro-articular process.

2. The second, and almost certainly spindle-shaped part of the *depressor mandibulae* starts at the end of the *processus paroticus* which overlaps caudally the upper end of the quadrate, and ends at the terminal muscular scar of the articular bone. Such a double *depressor mandibulae* is not rare in reptiles. The anterior and more lateral fan, because of the anteriorly directed curvature of the quadrate, would allow for sufficient room for the tympanic membrane under the posterodorsal part of the quadrate and along its ex-

ternal ridge; a vertically elliptical field would be left for it, sloping cranio-ventrally.

Stapedial traces. (Fig. 7).

Looking at the quadrate from a caudomedial direction (obliquely facing the internal and posterior surface of this bone), a vertically projecting facet forming a nearly straight, lateral border and a slight medial bay, being somewhat wider dorsally than ventrally, is very obvious. This slight prominence, 2 cm. under the inner, upper tip of the quadrate, is strictly symmetrically arranged on both sides, therefore not an accidental structure. There is no doubt that it had something to do with the stapedial apparatus. If it did not form the contact with the end of the stapes itself (a very improbable surmise) it certainly could have formed a contact with extrastapedial, cartilaginous structures or a ligament, linking extracolumellar parts with the quadrate. A *processus internus*, which is often linked with the posterior part of the quadrate, was most probably the structure adjacent to this little, but well elaborated, prominence. Perhaps, but less probably, conditions analogous to those in ophidians did exist in this dinosaur (implying a reduced tympanic cavity and membrane), where the stapes itself is linked with the quadrate by a cartilaginous intermediate nodule (the so-called stylohyal of the ophidians). Fig. 7 shows an artificial stapes inserted in situ, in order to show that this structure would not interfere with the position of the jaw muscles. Colbert and Ostrom describe several cases of preserved ear-ossicles in Dinosaurs, but in not a single one is an appositional facet at the upper posterior slope of the quadrate mentioned.

Discussion.

The whole differentiation of the jaw muscles in *Diplodocus* shows clearly, that the "awkward" angle of insertion and the peculiar forward thrust of the lower end of the quadrate, resulting in a disjunction of the lower temporal fossa from the upper one, by throwing the first directly under the orbit, precludes any substantial *biting power*.

Many authors have already described and discussed the very peculiar dentition of *Diplodocus*. But, besides the peculiar shape of the individual teeth and their exclusive disposition at the transversely truncated anterior ends of upper and lower jaws, respectively, the complete absence of any traces of wear is very remarkable. No doubt a scooping or combing out of the food from the water, a food which had to be swallowed without any mastication, was the only possible way of feeding. So far, floating water plants have always figured first as a possible source of food for *Diplodocus*. I feel quite unconvinced that such a source of nutrition could have been possible, especially if we take into account the certainly very low nutritional value of such a food and the very bulky mass of the body in contrast with a relatively extremely small "cropping apparatus." In the Jurassic period, especially in the Morrison beds, no substantial aquatic vegetable remains have been found together with the skeletal remains of the giant sauropods. Angiosperms must be excluded, and I do not know any "lower plants" frequent in fresh water and of a more substantial bulk which could be raked out from the water. Tough pteridophytes and *Characea* would not form an adequate food for such massive animals, and, especially, fronds of such plants, even if not

masticated (gastroliths!) would leave signs of use on the dentition owing to their rich mineral contents; but there is not a trace of any abrasion to be seen. This fact alone, together with the smallness of the head of *Diplodocus* and the poor nutritional value of any known fresh-water plants of this period induce me to put this problem again in the foreground. It should be stressed again that such a large animal could be dependent only on a floating food, occurring in great plenty and relatively rich in nutritional value. The scooping or raking of this submerged or floating food did not cause any abrasion; in other words, *Diplodocus* did not use its jaws for chewing but as a straining and raking device. The lateral posterior parts of the lower jaws, where teeth did not develop, were deeply overgrown and flanked by the sharp and vertically descending laminae of the maxillae; in fact, only the ends of the jaw apparatus were efficiently opened and closed again during this straining or raking operation. I see only one source of food which could fulfill the nutritional requirements of such a large animal; an invertebrate occurring in large numbers and large enough to be strained out by the very coarse device of the pencil-like fence of the dental series—relatively soft-shelled crustaceans of fairly large size and such enormous density that they could almost mechanically be scooped or raked out of the water, or as another alternative, relatively thin-shelled temporarily floating mollusks like lymnaeids, ampullariids or some other primitive pulmonates which have to surface in huge numbers in lagoon-like bodies of fresh water. Lamellibranchs could, in a similar way, have been sifted out of the soft mud of the bottom. Pulmonates very often form whole rafts at the surface of stagnant waters if the oxygen content in deeper water is getting low, especially under hot conditions. But even if such pulmonates did not really concentrate as whole carpets swimming at the surface (as I remember seeing in Anatolia in summer time), the raking in deeper layers could easily be done in soft mud or from algal or other ("higher") submerged plant thickets. Gastroliths would, together with an acid gastric juice, quickly dispose of the relatively thin shells of fresh-water mollusks (gastropods or lamellibranchs). I would infer, therefore, that the big sauropods depended on animal food, and I think that mollusks (or perhaps some very large crustaceans, living in enormous numbers) could have been the basic food of these gigantic animals, which lived and fed wholly or partly submerged.

Acknowledgments.

The author feels very much obliged and wishes to express his thanks to Dr. E. H. Colbert at the American Museum of Natural History, New York, and Dr. M. Graham Netting, at the Carnegie Museum, Pittsburgh, for their kindness in providing the author with the material needed for his investigation. My special thanks are due to Dr. Netting for having photographs taken of the specimen, C.M. 11161. Two of them are reproduced in this paper and the third formed the base for the reconstruction of the cranial muscles.

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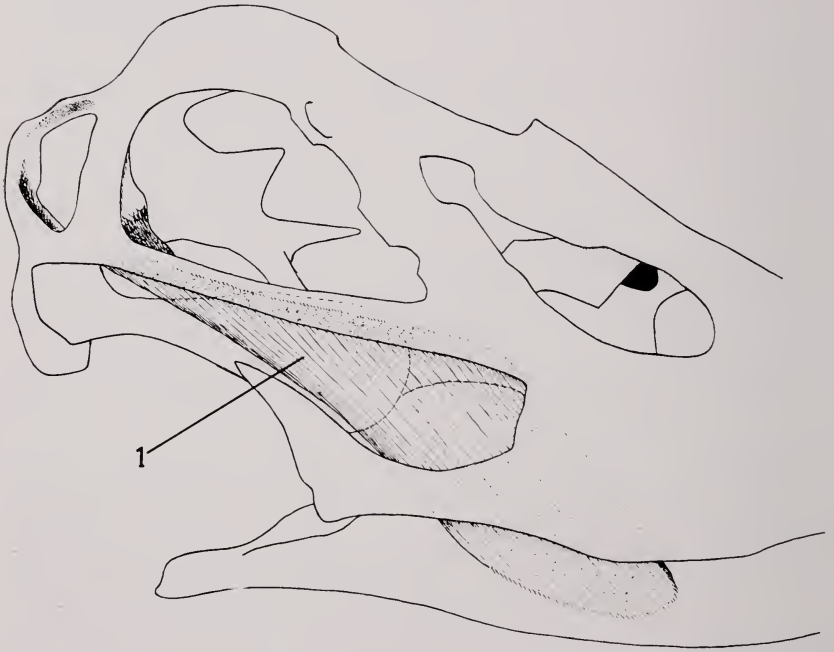


Fig. 1. Position of the *adductor mandibulae externus superficialis* (1)

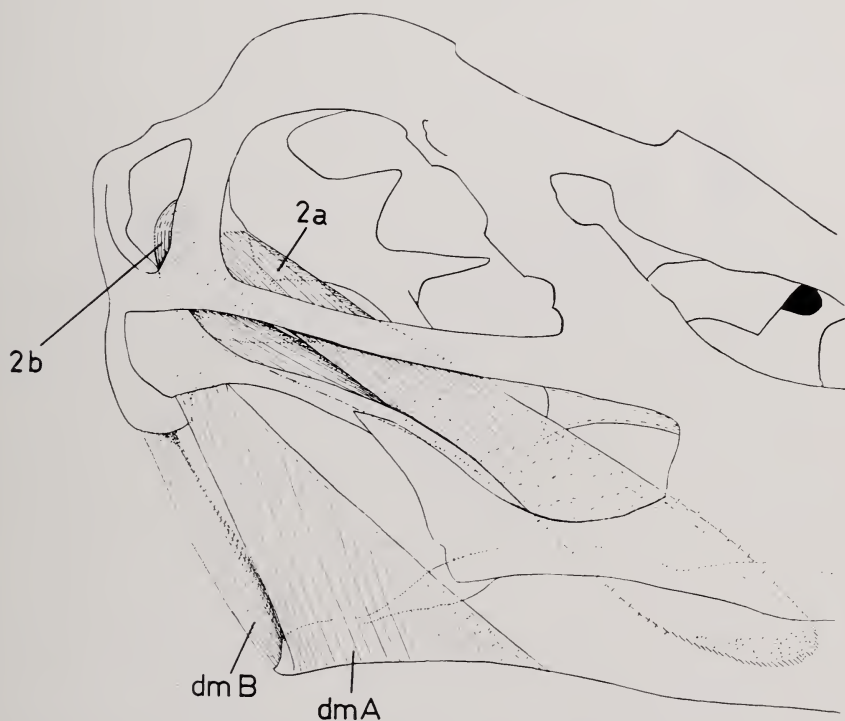


Fig. 2. The double *depressor mandibulae*. dmA inserts laterally at the retroarticular process, dmB at a strictly terminal insertional scar of the mandible. Both parts of the *adductor mandibulae externus medialis* are shown, rising from both surfaces of the postorbital bar and fusing anteroventrally according to the final interpretation given in the text. Portion 2a rises from the anterior, 2b from the posterior surface of the postorbital osseous frame

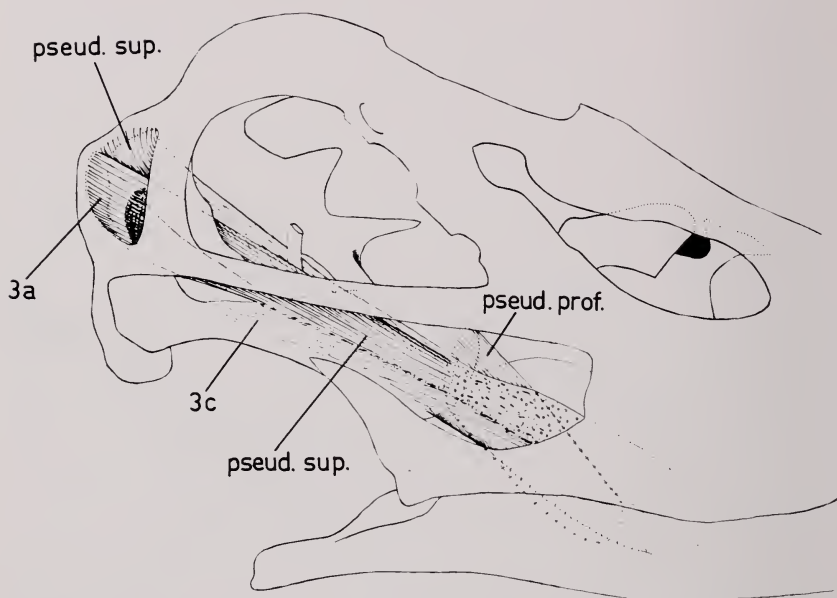


Fig. 3. Represents two of the three muscles bulging into the upper temporal fossa: the dorsomedial origin of the *pseudotemporalis superior* (pseud. sup.), and the posterolateral *adductor mandibulae externus profundus* (3a). A small part of the *pseudotemporalis profundus* (pseud. prof.) is visible at the scar of muscle origin from the "wing" of the quadrate. A rather doubtful portion, 3c, rising from the sloping anterior surface of the quadrate, has been added with some reluctance. Such a portion would have been partially fused with 3a and with the insertional aponeurosis of the pseudotemporalis group or both, but the trigeminal 3 had to pass downwards between 3a and 3c (laterally) and the pseudotemporalis group (medially). At the anteroventral corner of the upper temporal fossa the space of the scar of muscle origin of 2b is indicated as a concavity on the surface of 3a

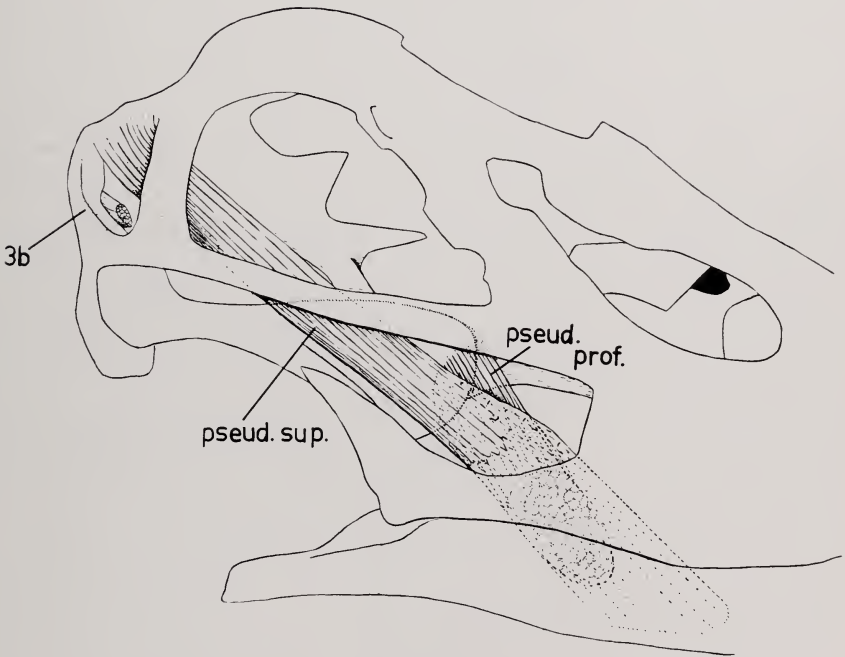


Fig. 4. Shows the emerging small portion 3b which joins 3a at its medial surface. Both parts of the *pseudotemporalis* (pseud. sup. and pseud. prof.) are drawn, but the insertions of the fused portions 3a and 3c at the surface of the *pseudotemporalis superficialis* and the common insertional aponeurosis have not been indicated specially. Compare with Fig. 3

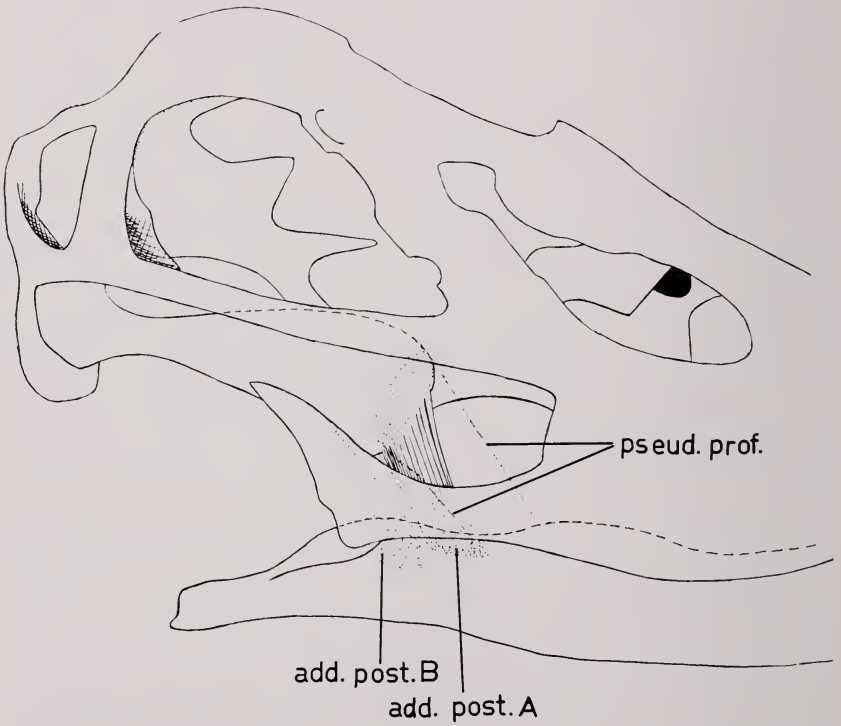


Fig. 5. The two distinct parts of the *adductor posterior* are shown. The anterior part is situated medially of the *pseudotemporalis profundus*, its contour indicated by the broken line

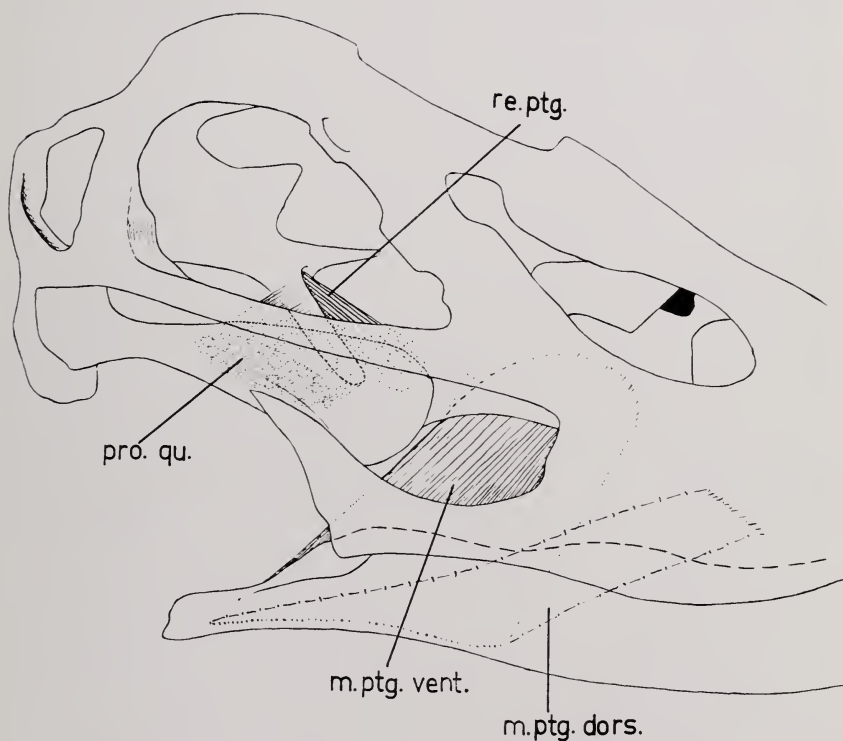


Fig. 6. Both parts of the *pterygoideus* are represented, partly in cross-hatching. The sloping *pterygoideus* "dorsalis" overlaps the insertion of the short-fibered *pterygoideus ventralis* near its insertion on the inner face of the mandible. The *protractor quadrati* (pro. qu.) and *retractor pterygoidei* (re. ptg.) are shown in their approximate positions



Fig. 7. Shows the position of an inserted artificial stapes (St.) and the ridge (R) at the posterior face of the postorbital shelf, facing the upper temporal fossa. Also shows the strongly projecting posteroventral rim of the orbit (X) and gives an idea of the shearing overlapping of the lower temporal arch across the mandible, with the shallow insertional scar on the latter for the *external adductor mandibulae* (1) muscle



Fig. 8. Shows clearly the ridge (R) at the postorbital shelf and the depression (D) for the scar of muscle origin of the adductor 3b

ART. 14. SCOLECODONTS FROM THE SHEFFIELD SHALE, UPPER DEVONIAN OF IOWA

By E. R. ELLER

Curator of Geology and Invertebrate Paleontology

Professor Doctor Klaus J. Müller, Technische Universität Berlin, West Berlin, Germany, has kindly given me for description a suite of scolecodonts, fossil polychaete annelid jaws, collected and prepared by him in 1956. The specimens came from 25 feet below the top of the formation at the Sheffield type locality in the pit of the Sheffield Brick and Tile Company, just south of the town of Sheffield, Section 8, T934N, R20W, Franklin County, Iowa. The Sheffield shale is correlated with the Upper Devonian (Canadaway) of New York. Besides the scolecodonts this bed contains conodonts and casts of poorly preserved brachiopods. On the basis of the conodonts the age of the Sheffield shale may be Lower Famennian. The scolecodont fauna does not correspond to any other described material although some comparisons might be made with the Alfred, New York, forms if they were better illustrated and described.

DESCRIPTION OF SPECIES

Genus *ARABELLITES* Hinde, 1879

Arabellites demissicius sp. nov.

Maxilla I. Plate 1, Fig. 1-5, 8

The jaw is elongate and the figured specimens measure from about 0.76 mm. to 1.08 mm. in length. Along the nearly straight inner margin a series of ten large, conical, slightly backward directed denticles extends about three-quarters the length of the jaw. The fang is large and usually hooked slightly backward. The first denticle is directed forward and in most specimens follows closely the posterior edge of the fang. The next three or four denticles are large, sharp-pointed and widely spaced. These are followed by smaller denticles which gradually decrease in size posteriorly. A wide fossa occupies about one-third of the jaw. The margins of the fossa are thickened and rounded. A hooked spur-like attachment is present on the outer margin at the upper end of the fossa. The posterior end narrows to a truncation that is about half the greatest width of the jaw.

There is a resemblance between *Arabellites demissicius* and *Arabellites comis* (1938) and *Arabellites oblatius* Stauffer (1939). They differ in the general shape of the posterior end and the truncation. The shape and arrangement of the denticles are similar except for the first one. The spur of *Arabellites demissicius* seems to be more prominent and definitely hooked than the specimens of *Arabellites comis* Eller described by Stauffer (1939), Eller (1938, 1941) and Sylvester (1959).

Arabellites divaricatus sp. nov.

Maxilla I. Plate 1, Fig. 13

Anteriorly the jaw is narrowly elongate and widens abruptly at the posterior end. Only four small, conical, widely separated denticles are present on the inner margin. The fang is long, narrow, sharp-pointed and slightly hooked. The outer margin is irregularly curved ending in a blunt, spur-like projection

at the posterior extremity. A small, narrow fossa is present on the upper surface.

This form can not be compared very closely with other species of *Arabellites*. It has a spur-like projection that is similar to *Arabellites comis* Eller (1939, 1941), *Arabellites demissicius* Plate 1, Fig. 1-5, and *Arabellites duplicostatus* Plate 1, Fig. 6-7. The fossa and the number, size and arrangement of the denticles are dissimilar to other forms.

Arabellites duplicostatus sp. nov.

Maxilla I. Plate 1, Fig. 6-7

The jaw is elongate and becomes widest at the posterior end. The figured specimen measures 1.35 mm. in length. On the nearly straight inner margin a series of 13 conical, blunt to sharp, denticles extends more than three-quarters the length of the jaw. A large fang is conical, sharp-pointed and hooked backward. The next three denticles are small and blunt. These are followed by backward-directed denticles that become larger to about the mid-point and decrease gradually in size posteriorly. On the outer margin a notch occurs at about the mid-area and forms the anterior side of a large, hooked, conical shaped spur. A small shank widens the truncated posterior extremity. A deep fossa occupies more than one-third of the upper side of the jaw. Adjacent and anterior to the fossa the jaw is depressed or plicated.

This species does not seem to be too closely related to any other form. The presence of a spur suggests a similarity to *Arabellites comis* Eller (1938, 1941) and *Arabellites demissicius*, Plate 1, Fig. 1-5, 8. The denticles, the broadly truncate posterior and the large fossa place it apart from other species of this genus.

Genus NEREIDAVUS Grinnel, 1877

Nereidavus difficilis sp. nov.

Maxilla I. Plate 1, Fig. 9

The jaw is long and narrow with curved inner and outer margins. The figured specimens measure about 0.97 mm. in length. Along the inner margin a series of 10 to 12 denticles extends three-quarters the length of the jaw. The first five or six denticles are small and rounded while the remaining five or six are large, conical and sharp-pointed. The fang is broad posteriorly and tapers abruptly to a sharp-pointed extremity. A deep, narrow fossa occupies about one-third the posterior area along the outer margin of the jaw. The posterior extremity is narrow and rounded.

The denticles of *Nereidavus difficilis* are somewhat similar to *Nereidavus decoctus*, Plate 1, Fig. 11-12, but the fossa and posterior areas do not resemble each other.

Nereidavus diversus sp. nov.

Maxilla I. Plate 1, Fig. 10

Both the inner and outer margins are curved and the angle of the jaw to the horizontal shows some obliquity. The figured specimen is 0.65 mm. in length. Along the inner margin a series of 14 to 15 small, sharp-pointed denticles extends for about three-fourths the length of the jaw. The first few denticles are directed anteriorly, the next four or five perpendicular to the margin, while the remaining ones point backward. A deep, medium narrow fossa occupies the posterior quarter of the jaw. The margin of the fossa is

thickened and forms a small shank at the outer margin. The posterior extremity is narrowly truncate.

Grinnell (1877) erected the genus *Nereidavus* for Maxilla I of this type. They have been found in large numbers throughout the Paleozoic and many species have been described. Most workers have used this genus and there does not seem to be a valid reason to create a new one even though a jaw of this type may be found articulated with the remainder of the jaw apparatus. When various parts of a plant or animal are first described separately before a complete specimen is known the first name used should have priority. There is a general similarity in form and outline of *Nereidavus hamatus* (Hinde) (1882), *Nereidavus perlongus* Eller (1934), *Nereidavus harbisonae* Eller (1941), *Nereidavus paranaensis* (Lange) (1949) and *Nereidavus burgensis* (Mastinsson) (1960) to *Nereidavus diversus*. In each case the arrangement, shape and size of the denticles fail to correspond.

Nereidavus decoctus sp. nov.

Maxilla I. Plate 1, Fig. 11-12

The jaw is elongate and thick. The figured specimen measures 0.7 mm. in length. Both the inner and outer margins are curved and they terminate in a wide, truncate posterior. Along the inner margin a series of 13 or 14 conical, sharp-pointed, backward-directed denticles extends to the posterior quarter of the jaw. The first few denticles are not small but become larger at the mid-area and then decrease in size posteriorly. The fang is large, thick and hooked. A large, shallow fossa occupies about one-third of the jaw. The margin of the fossa is thickened and the upper part terminates in a small spur at the outer margin.

Nereidavus decoctus is similar to *Nereidavus distinctus*, Plate 1, Fig. 15, except for the shape, size and arrangement of the denticles.

Nereidavus digitus sp. nov.

Maxilla I. Plate 1, Fig. 14

The figured specimen is large, elongate and measures 1.95 mm. in length. The anterior end terminates in a heavy, sharp-pointed, forward-directed fang. On the inner margin a series of 12 or more very small denticles extends about to the midpoint of the jaw. They gradually decrease posteriorly to such a small size that it is difficult to detect them. The inner and outer margins are curved and the jaw has a tendency to obliquity. A very large but shallow fossa occupies about one-third the area of the jaw. The margins of the fossa are heavy, raised and rounded. At the posterior end of the inner margin a large shank curves downward and is difficult to see when the jaw is in a natural position. The posterior end is truncate.

There is a slight similarity between *Nereidavus perlongus* Eller (1934) and *Nereidavus digitus* in the arrangement and size of the fang and denticles.

Nereidavus distinctus sp. nov.

Maxilla I. Plate 1, Fig. 15

In contour the jaw is large and thick with nearly straight inner and outer margins. The figured specimen measures 1.87 mm. in length. Along the inner margin a series of 12 to 14 denticles extends about three-quarters the length

of the jaw. The last five or six denticles are minute and gradually blend into a sharp ridge posteriorly that may have been used as a cutting edge. A large, thick, angular and blunt fang is directed perpendicularly to the margins of the jaw. The fossa is large and shallow. It terminates in a truncate posterior extremity. The margins of the fossa are thickened, angular and well defined. The anterior margin is extended to a blunt spur at the outer margin of the jaw.

The gradual disappearance of the denticles to form a knife-like ridge on the inner margin has not been observed in other forms. The anterior denticles of *Nereidavus distinctus* are distinct from others of this genus.

Nereidavus muelleri sp. nov.

Maxilla I. Plate 1, Fig. 16

In outline the jaw is wide posteriorly and tapers gradually to a blunt forward and obliquely directed fang. The figured specimen measures 1.82 mm. in length. Along the inner margin a series of small, blunt, nearly uniform denticles extends just slightly beyond the midpoint of the jaw. The first two denticles are widely spaced while the posterior ones are compact. A large, deep to shallow fossa occupies about one-quarter of the posterior part of the jaw. Beginning at the middle of the fossa at the posterior end a well defined ridge continues to the anterior end to form a slightly concave and rounded spur at the outer margin. The margins of the fossa are thin and rounded.

Nereidavus muelleri does not correspond very closely to other species of this genus. It differs in shape and arrangement of the denticles and fossa.

Nereidavus disjunctus sp. nov.

Maxilla I. Plate 1, Fig. 17-18

In outline the jaw is angular especially at the truncated posterior end. The outer margin is rounded while the inner margin is nearly straight. Specimens measure as much as 1.97 mm. in length. On the inner margin a series of 10 to 16 large, rounded and low denticles extends about two-thirds the length of the jaw. When the denticles are few in number the posterior ones seem to blend gradually into the structure of the inner margin. The first five or six denticles are widely separated while the remaining ones are close together. A large angular fang is directed slightly backwards. Both denticles and fang are nearly at right angles to the lower side of the jaw. In this position they would point downward in the annelid's oral cavity. A large, angularly shaped fossa occupies the posterior end of the jaw. Beginning at the posterior end of the fossa a small rounded ridge extends diagonally toward the outer margin to about the mid-area. This structure is not reflected on the obverse side. On the under side opposite the fossa is an oval, concave area inclosed by rounded ridges. The margins of the fossa are thick and rounded, and terminate at the anterior end at the outer margin in a blunt spur the surface of which is concave when observed from the upper side. The inner margin at the posterior end is extended to form an angular shank.

The denticles of *Nereidavus disjunctus* are similar to those of *Nereidavus distinctus*, Plate 1, Fig. 15, and *Nereidavus muelleri*, Plate 1, Fig. 16, in a general way. The fossa and the very sharply truncated posterior end of *Nereidavus disjunctus* do not correspond to these structures in other species.

Genus *LEODICITES* Eller, 1940*Leodicites demissus*, sp. nov.

Maxilla II. Plate 2, Fig. 1-2, 5, 7

In shape the jaw is large, wide, subtriangular and arched. The figured specimens measure 0.6 mm. to 1.17 mm. in length. Along the curved inner margin a series of six to eight large, blunt denticles extends nearly to the acute posterior extremity. In most specimens the first denticle is small although in some specimens it is large. In mature specimens it is suggested that the first denticle has disappeared. The denticles increase to a very large size at the mid-area and decrease gradually to the posterior. The anterior margin is curved from the first denticle and becomes nearly straight to the blunt shank. From the shank to the posterior end the surface of the margin is thick and ridged. A narrow fossa extends nearly the full length of the jaw. The under side of the jaw is deeply depressed.

Most of the specimens of *Leodicites demissus* are incomplete along one margin. The denticles of *Leodicites diffusus* Eller (1946) are similar to *Leodicites demissus* in a general way.

Leodicites descriptus sp. nov.

Maxilla II. Plate 2, Fig. 13-14

The jaw is elongate, narrow and subtriangular in shape. Specimens measure from 0.80 mm. to 0.85 mm. in length. Along the nearly straight inner margin a series of 10 to 12 precisely arranged sharp-pointed, triangularly shaped denticles extends to the acute posterior extremity. Except for the first and third denticles which are small to minute the denticles are very large when compared to the width of the jaw. Except for the first one all denticles are directed backward and they decrease in size gradually to the posterior end. In some specimens the second denticle is larger than average. A slight incurved anterior margin terminates in a narrow, curved, fairly acute shank. A curved, rather deep bight is formed by the shank and the outer margin. The upper side of the jaw is convex while the under side is concave except at the posterior end where it is flattened. A deep, narrow fossa beginning in the shank extends the full length of the jaw. The margin of the fossa is slightly thickened and rounded.

The lateral margins of *Leodicites descriptus* are straighter than found in most forms. Also the jaw is long when compared to its width. *Leodicites descriptus* is similar to *Leondicites artus* Eller (1945) except for the shape and character of the denticles and shank. There is a resemblance between *Leodicites descriptus* and *Leodicites variedentatus* Eller (1940). They differ in the shape of the fossa and the arrangement of the denticles.

Leodicites declivis sp. nov.

Maxilla II. Plate 2, Fig. 18

In shape the jaw is large, wide and subtriangular. The figured specimen measures 1.72 mm. in length. Along the curved inner margin a series of 12 inclining, blunt, triangularly shaped denticles extends nearly to the pointed posterior extremity. The first two denticles are small to minute. The third denticle is a very large one and it is followed by two smaller denticles. The

remaining ones are large and decrease gradually in size posteriorly to the last two denticles which are minute. All denticles are directed backward and they tend to be close together or slightly overlap each other posteriorly. The anterior margin is rounded and becomes slightly incurved to form a pointed shank. A deep, large fossa occupies about two-thirds of the upper surface of the jaw. A thickened and rounded margin surrounds the fossa except along the inner margin where it becomes wide and flattened. The under surface of the jaw is concave while the upper surface is convex.

In shape *Leodicites declivis* resembles *Leodicites altilis* Eller (1955) very closely. They differ in the shape and width of the fossa and the arrangement of the denticles.

Leodicites divexus sp. nov.

Maxilla II. Plate 2, Fig. 19

The jaw is narrow, elongate and thick. The figured specimen measures 0.67 mm. in length and 0.27 mm. in width. Along the curved inner margin a series of 13 or 14 conical, sharp-pointed, medium-sized, backward-directed denticles extends nearly to the posterior end. The first two denticles are small and are followed by two that are large. The fifth denticle is minute and the remaining denticles are large. They decrease in size very gradually to the posterior. The anterior margin is rounded and forms a downward-sloping, sharp-pointed and hooked shank. The bight formed by the shank and the outer margin is deep and narrow. A fossa beginning in the shank extends to the wide and rounded posterior extremity. The fossa is deep and narrow. The margins of the fossa are thickened and rounded. The upper side of the jaw is highly convex while the under side is concave.

Leodicites divexus is similar to *Leodicites variedentatus* Eller (1940) in the shape of the jaw and character of the fossa. They differ in the arrangement of the denticles, the shape of the shank and width of the jaw.

Genus UNGULITES Stauffer, 1933

Ungulites dactyliiformis sp. nov.

Maxilla III or IV. Plate 2, Fig. 6

The jaw is small and subrectangular in outline. The figured specimen measures 0.22 mm. in length and 0.37 mm. in width. Along the nearly straight inner margin a series of six long, conical, sharp-pointed denticles extends the full length of the jaw. The first denticle is much larger than the nearly uniform ones that follow. The outer margin is rounded and usually broken while the posterior margin is nearly straight. A large, deep fossa occupies about two-thirds of the upper side of the jaw.

Ungulites dactyliiformis is similar to some of the specimens described as *Ungulites mutabilis* (Eller) (1934). It differs in the large size of the first denticle.

Genus OENONITES Hinde, 1879

Oeononites ? sp.

Maxilla II. Plate 2, Fig. 3-4, 9

Several poorly preserved or broken specimens are questionably referred to this genus. There is a slight similarity of these forms to *Oeononites triangulus* Eller (1940).

Genus PALEOENONITES Eller, 1942

Paleoenonites deltoides, sp. nov.

Maxilla II. Plate 2, Fig. 8

In shape the jaw is irregularly rectangular and the width is nearly equal to the length of the jaw. The figured specimen measures 0.45 mm. in length. Along the slightly curved inner margin a series of nine sharp, conical denticles extends nearly to the posterior end. The first deltoid-shaped denticle or fang is large, angular, and points in a forward direction while the other denticles are nearly perpendicular to the margin of the jaw. They decrease in size gradually to the posterior. The anterior margin is irregularly curved and forms a wide angle with the thin outer margin. The posterior margin is wide and forms nearly a right angle with the lateral margins. A wide, angular, shallow fossa occupies about two-thirds of the upper surface of the jaw. The margins of the upper side of the fossa are thickened and rounded.

Paleoenonites deltoides is similar to *Paleoenonites auctificus* Eller (1955). They differ especially in the angularity of the fossa and the shape of the fang.

Genus ILDRAITES Eller, 1936

Ildraites decorus, sp. nov.

Maxilla I. Plate 2, Fig. 11-12

The jaw is large, narrow, and tapers to a pointed posterior extremity. The figured specimens measure 1.07 mm. and 1.22 mm. in length. On the slightly curved inner margin a series of rather large, conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. The first denticle is very large, narrow, and hooked. A very small denticle is located in the wide space between the fang and the third denticle. The remaining denticles decrease in size very slightly except at the posterior extremity where they are minute. The outer margin incurves slightly to form a narrow, acutely pointed shank. The fossa is narrow, shallow, and extends from the end of the shank to the posterior end of the jaw. The margins of the fossa are thickened and rounded.

Ildraites bowenensis Eller (1941) resembles *Ildraites decorus* except for the presence of the small denticles and the large size of the fang and the narrowness of the fossa.

Ildraites demarchus, sp. nov.

Maxilla I. Plate 2, Fig. 20-21

The jaw is large and narrowly subtriangular in shape. The figured specimen measures 1.85 mm. in length and 0.77 mm. in width. Smaller specimens are of about the same proportions. Along the inner margin a series of 12 or more, often irregularly shaped, denticles extends nearly to the acute posterior end. The first denticle or fang is heavy and in some specimens rather short. The space between the fang and the next large denticle may contain from one to three small teeth. In some specimens the first few denticles seem to be deformed into an outward growth or are represented by poorly developed denticles. The remainder of the denticles may be rounded to triangular and blunt to sharp pointed in shape. They decrease in size to the posterior end. The denticles have a tendency to be at an angle with the underside of the jaw. The outer margin incurves slightly to form a large, curved blunt shank. A shallow, crescent-shaped bight on the outer margin emphasizes the curva-

ture of the shank. A narrow, rather deep fossa is located in the posterior half of the jaw. When viewed from the upper side the area adjacent to the fossa is convex and the inner margin is extended to form an angular and broad flange. The margins of the fossa are slightly thickened and rounded. The under side of the jaw is flattened and slightly concave in the area of the shank. The upper side in the anterior end is convex at the outer margin but flattened adjacent to the denticles.

In outline *Ildraites demarchus* is similar to *Ildraites howelli* Eller (1941) but in other details there is very little likeness. *Arabellites anglicus* Hinde (1880) is somewhat like *Ildraites demarchus* except that the denticles are of a different character and the shank is not similar. *Arabellites dauphinensis* Stauffer (1933) has a fang similar to *Ildraites demarchus* but the denticles and shank do not correspond.

Genus MARPHYSAITES Eller, 1945

Marphysaites deliguus, sp. nov.

Carrier. Plate 2, Fig. 10

The carrier is very large and the figured specimen is estimated to be 1.1 mm. in length. The thickened anterior margin is straight and terminates in a notch at the outer margin. Just adjacent to the outer margin at the anterior end the carrier is concave but becomes slightly convex posteriorly. The inner margin incurves slightly at the anterior end and then curves broadly outward. The outer margin is incurved. The carrier probably narrows gradually to an acute posterior extremity which is lacking.

The only specimens that this carrier might support are those described under the genus *Nereidavus*. As far as can be determined the carriers of recent species of this type have straight inner margins that are joined. Based on the mandibles of the modern genus *Marphysa* and since all fossil articulated specimens known at that time, Hinde (1896), Eller (1934, v. 22) and Eller (1934, v. 24), show articulation along the inner margin, the form *Maryphysaites aptus* Eller (1945) was described as a mandible. Lange (1949), however, found carriers that belong to *Nereidavus paranaensis* (Lange) that are joined only at the anterior end. Thus *marphysaites deliguus* is described as a carrier and not as a mandible.

Genus DIOPATRAITES Eller, 1938

Diopatraites dichotomus, sp. nov.

Mandible. Plate 2, Fig. 16

The mandible is narrow, elongate and straight. The figured specimen measures 0.9 mm. in length. The frontal plate is small, convex, and subrectangular in shape. A small notch is present on the rounded anterior end. The posterior margin of the frontal plate is rounded and notched. A groove extends between the two notches dividing the plate into two parts. The inner section of the plate is larger and more convex than the outer area. The surface of the outer side of the plate is irregularly grooved and the margin is angular. Faint striations ornament the surface. The shaft is long and tapers gradually from the frontal plate to an acute posterior extremity. The upper side of the shaft is convex while the under side is concave.

Diopatraites dichotomus resembles other species only in a general way. The frontal plate is dissimilar.

Diopatraites digonus, sp. nov.

Mandible. Plate 2, Fig. 17

The mandible is narrowly elongate and the figured specimen measures 0.7 mm. in length. The frontal plate is small, convex and two-cornered or subrectangular in shape. The anterior end is angular and terminates in an acute extremity or tooth while the posterior end of the plate is rounded. Very fine striations follow the margins and contours of the plate. The shaft is long and the sides are parallel to about the midpoint where they taper to an acute posterior extremity. The upper surface of the shaft is slightly flattened or concave at the margins. The under side is highly concave.

The shape of the shaft and anterior end of the frontal plate make *Diopatraites digonus* different from other species.

Genus *SILUROPelta* Eisenack, 1939

Siluropelta dejectus, sp. nov.

Carrier. Plate 2, Fig. 15

The carrier is wide and the figured specimen, although broken, measures about 0.57 mm. in length and 0.30 mm. in width. The straight inner margin is wide and thick. It incurves slightly anteriorly and continues to form an angular shaft. Part of the shaft is missing. The area adjacent to the shaft and inner margin is sunken or concave while the area at the outer margin is convex. The outer margin is well rounded to the truncate posterior.

Eller (1945) described *Siluropelta calcaratus* as a mandible and not as a carrier since it did not seem possible for a specimen with a long thin shaft or spur to fit into the upper part of the oral cavity. Eisenack (1934) described similar forms as carriers. The mandibles of a recent species, *Paramarphysa obtusa* Verrill do have long spines or shafts. Based on recent Polychaete genera, *Stauroneries*, *Arabella*, *Agaurides*, *Diopatra*, *Leodice*, *Onuphis* and others, Eller (1946) reversed the orientation so that the shaft would point backward. Kozłowski (1956), however, figured forms of this sort as carriers (supports) having the shafts pointing forward in articulation with the jaw apparatus.

EXPLANATION OF PLATE 1

Figures magnified about 28 times.

Numbers in parenthesis indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1-2. *Arabellites demissicius* sp. nov.
Maxilla I, right jaw (28619).
Under and upper sides.
- Fig. 3-4. *Arabellites demissicius* sp. nov.
Maxilla I, left jaw (28621).
Under and upper sides.
- Fig. 5. *Arabellites demissicius* sp. nov.
Maxilla I, right jaw (28624).
Upper side.
- Fig. 8. *Arabellites demissicius* sp. nov.
Maxilla I, left jaw (28626).
Upper side.
- Fig. 6-7. *Arabellites duplicostatus* sp. nov.
Maxilla I, left jaw (28627).
Lateral sides.
- Fig. 13. *Arabellites divaricatus* sp. nov.
Maxilla I, left jaw (28628).
Upper side.
- Fig. 9. *Nereidavus difficilis* sp. nov.
Maxilla I, left jaw (28631).
Upper side.
- Fig. 10. *Nereidavus diversus* sp. nov.
Maxilla I, right jaw (28634).
Upper side.
- Fig. 11-12. *Nereidavus decoctus* sp. nov.
Maxilla I, left jaw (28637).
Under and upper sides.
- Fig. 14. *Nereidavus digitus* sp. nov.
Maxilla I, right jaw (28639).
Upper side.
- Fig. 15. *Nereidavus distinctus* sp. nov.
Maxilla I, left jaw (28643).
Upper side.
- Fig. 16. *Nereidavus muelleri* sp. nov.
Maxilla I, right jaw (28650).
Upper side.
- Fig. 17-18. *Nereidavus disjunctus* sp. nov.
Maxilla I, right jaw (28651).
Under and upper sides.

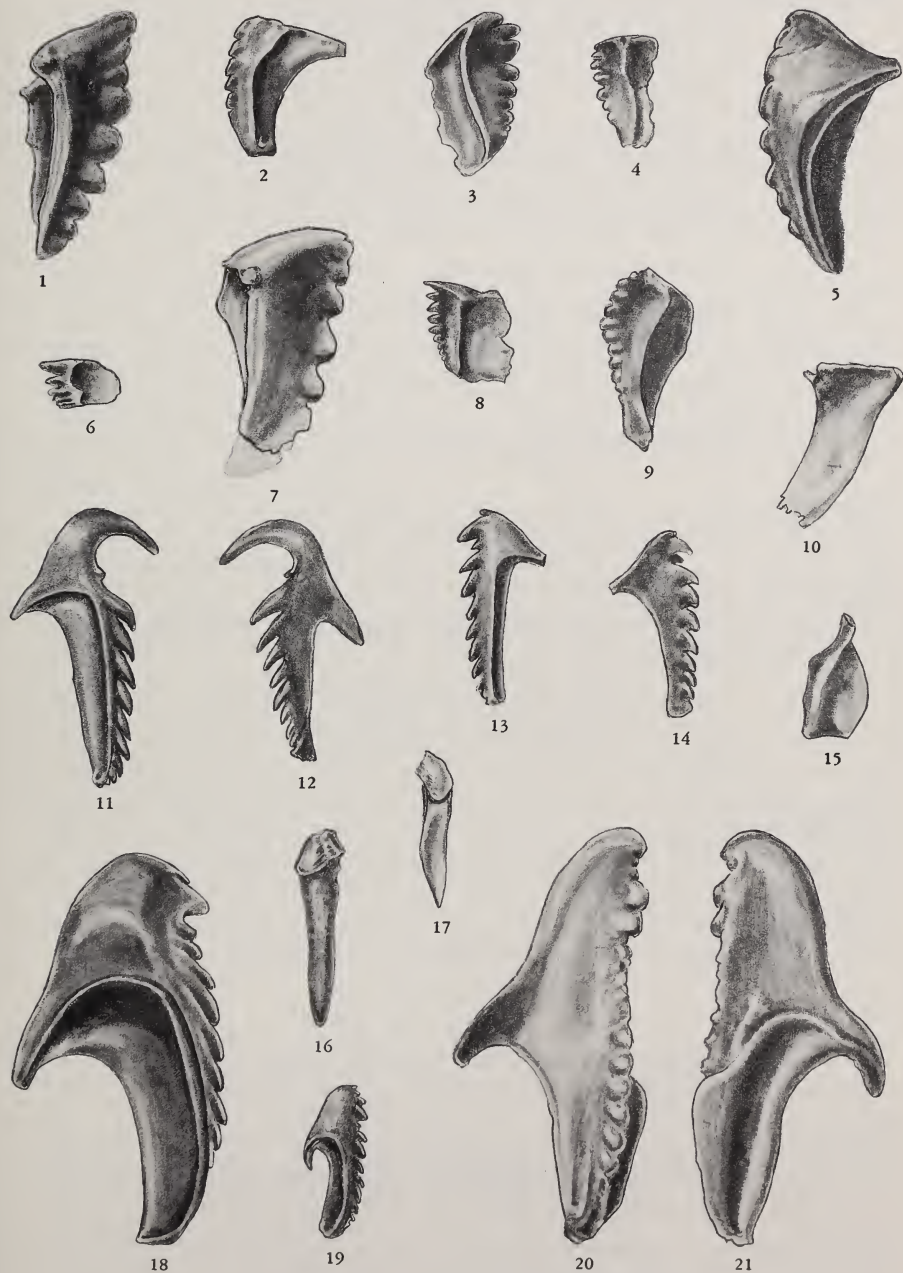


EXPLANATION OF PLATE 2

Figures magnified about 28 times.

Numbers in parenthesis indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1, 5. *Leodicites demissus* sp. nov.
Maxilla II, right jaw (28657).
Under and upper sides.
- Fig. 2. *Leodicites demissus* sp. nov.
Maxilla II, right jaw (28658).
Upper side.
- Fig. 7. *Leodicites demissus* sp. nov.
Maxilla II, right jaw (28659).
Under side.
- Fig. 13-14. *Leodicites descriptus* sp. nov.
Maxilla II, right jaw (28666).
Upper and under sides.
- Fig. 18. *Leodicites declivis* sp. nov.
Maxilla II, left jaw (28671).
Upper side.
- Fig. 19. *Leodicites divexus* sp. nov.
Maxilla II, left jaw (28678).
Upper side.
- Fig. 6. *Ungulites dactyliformis* sp. nov.
Maxilla II or IV, right jaw (28681).
Upper side.
- Fig. 3. *Oeononites* ? sp.
Maxilla II, left jaw (28682).
Upper side.
- Fig. 4. *Oeononites* ? sp.
Maxilla II, right jaw (28683).
Upper side.
- Fig. 9. *Oeononites* ? sp.
Maxilla II, right jaw (28684).
Upper side.
- Fig. 8. *Paleoeononites deltoides* sp. nov.
Maxilla II, right jaw (28688).
Upper side.
- Fig. 11. *Ildraites decorus* sp. nov.
Maxilla I, left jaw (28691).
Upper side.
- Fig. 12. *Ildraites decorus* sp. nov.
Maxilla I, left jaw (28691).
Under side.
- Fig. 20-21. *Ildraites demarchus* sp. nov.
Maxilla I, right jaw (28692).
Under and upper sides.
- Fig. 10. *Marphysaites deliguus* sp. nov.
Carrier. (28699).
Upper side.
- Fig. 15. *Siluropelta dejectus* sp. nov.
Carrier. (28704).
Under side.
- Fig. 16. *Diopatraites dichotomus* sp. nov.
Mandible, left shaft (28700).
Upper side.
- Fig. 17. *Diopatraites digonus* sp. nov.
Mandible, right shaft (28701).
Upper side.



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ART. 15. SCOLECODONTS FROM THE DUNDEE, DEVONIAN OF MICHIGAN

By E. R. ELLER

Curator of Geology and Invertebrate Paleontology

A small collection of scolecodonts, fossil polychaete annelid jaws, is described from the Dundee limestone at Dundee, Michigan and from the Sibley Quarry, Trenton, Michigan. The Dundee limestone is recorded as being the same age as the Marcellus of New York and equivalent to the Delaware limestone of Ohio.

Most of the jaws were very poorly preserved. This is very unusual. When jaws are dissolved out of limestone in a five per cent solution of hydrochloric acid they are nearly always in a very fine state of preservation. Many of the jaws look as though they had been partly eaten away by the acid. Only a small amount of matrix was available at the quarry at Dundee, the type locality of the Dundee limestone. As samples were being taken a dump truck arrived and covered the last exposure of the outcrop. Specimens were not too plentiful at either locality. If additional material was dissolved it is certain that many more forms could be found.

Originally these specimens were collected to make comparisons with a large suite of scolecodonts secured from cuttings from a deep well in the Kawkawlin Field, Michigan, between 2860½ feet and 2937½ feet below the surface. The samples from the well were recorded as Dundee limestone in the log. Studies have shown, Eller (1961), that only one species, *Lumbriconerutes cooperi*, a long-range form, is common to the Dundee limestone and the well samples.

Genus EUNICITES, Ehlers, 1868

Eunicites effusus sp. nov.

Maxilla IV. Plate 1, Fig. 1

In outline, the jaw is subtriangular measuring 0.55 mm. in length and 0.90 in width. The jaw consists of a large, heavy base and a small, narrow denticle that tapers gradually to a sharp point. An irregular, rectangular-shaped fossa occupies most of the upper side of the jaw. The margins of the fossa are thin and usually broken. The under surface has a concave area located centrally.

Eunicites effusus is dissimilar to most forms. The smallness and central location of the tooth together with the concave area make it different from other species.

Eunicites extensus sp. nov.

Maxilla IV. Plate 1, Fig. 2-4

The jaw consists of a single, large angular denticle that tapers to a sharp point. The tooth is slightly hooked. The figured specimens measure from 0.17 mm. to 0.42 mm. in length, and from 0.35 mm. to 0.72 mm. in width. The upper side of the jaw is occupied by a large, wide, rectangular or irregularly rectangular fossa. Adjacent to the fossa on some specimens is a wide base or shank. The under side of the jaw is convex while the upper side is concave especially at the outer end.

Except for some general features, this species is unlike other forms because of the wide base or shank and the angularity of the fossa.

Eunicites euconus sp. nov.
Maxilla IV. Plate 1, Fig. 5

The jaw is a single denticle measuring 0.30 mm. in length and 0.40 mm. in width. The hooked denticle is slightly flattened and tapers to a sharp pointed end. Perpendicular and surrounding the base of the denticle is an irregularly shaped flange that is thin and broken. A deep, round fossa is situated at about the center of the base or flange.

A number of forms resemble *Eunicites euconus* in a general way but the base or flange completely surrounding the fossa and perpendicular to the denticle makes it different specifically.

Eunicites ? sp.
Maxilla IV. Plate 1, Fig. 6

This jaw is not complete enough for description due to poor preservation and crushing. A considerable part of the jaw must be missing since there is no evidence of a fossa. Along one margin there is a suggestion of denticles similar to *Eunicites* ? *alienus* Eller (1955) but this may be only an unevenness of the edge.

Genus PALEOENONITES Eller, 1942

Paleoenonites exsertus sp. nov.
Maxilla II. Plate 1, Fig. 7-8

The jaw is large, subtriangular in shape, wide anteriorly and tapers gradually to a blunt posterior extremity. The figured specimen measures 1.12 mm. in length. Due to the broken margins the width of the jaw can not be taken. Along the curved or nearly right angled inner margin a series of eight large, blunt, conical denticles extends the full length of the jaw. The first denticle is usually slightly longer but not as wide as most of the denticles. The four anterior denticles are close together while the posterior ones are widely spaced. From the fourth denticle they decrease in size posteriorly. The outer margin on the upper side is thick, irregular, and usually broken. It forms a shank with the anterior margin. A triangularly shaped fossa, wide anteriorly but very narrow posteriorly occupies the upper side of the jaw. From the anterior part of the fossa a narrow ridge is projected posteriorly to form one of the outer margins. Due to the angle formed by the outer margin at the anterior end a deep concave area is present on the under side of the jaw.

Paleoenonites exsertus is not particularly similar to other forms. The angularity of the inner margin, the shape of the fossa, and the size and arrangement of the denticles are different.

Paleoenonites editus sp. nov.
Maxilla II. Plate 1, Fig. 9

In the outline the jaw is subtriangular. The figured specimen is large and measures 0.77 mm. in length. Along the slightly curved inner margin a series of eight or nine sharp pointed to blunt denticles extends the full length of the jaw. The first denticle is long, narrow and sharp pointed. The second is smaller and flattened while the third is larger and also flattened. The remaining denticles are large and rounded and decrease in size gradually to the posterior end. The anterior margin is straight, elevated and thickened. The outer margin on the upper side is irregular and usually broken. It forms a large shank with the anterior margin. A long, narrow triangular-shaped fossa

occupies the upper side of the jaw. One of the lateral margins of the fossa is thickened, elevated and rounded. The upper side of the jaw is convex while the under side is concave.

There is a slight resemblance between *Paleoenonites editus* and *Paleoenonites clinatus* Eller (1945.) They have similar straight and thickened anterior margins. They differ in the curvature of the inner margin and the arrangement and character of the denticles.

Genus STAUROCEPHALITES Hinde, 1879

Staurocephalites eucharis sp. nov.

Maxilla II. Plate 1, Fig. 10

The jaw is elongate, slightly arched and the figured specimen measures 0.80 mm. in length. A series of twelve large, graceful, sharp-pointed, conical, backward-directed denticles extends nearly to the posterior end. The first denticle is larger than the second. Beginning with the third denticle they increase in size to about the mid-point and then decrease in size gradually to the posterior. The anterior end is straight and slightly oblique while the posterior end is rounded. The inner margins are thin and broken. A narrow fossa extends nearly to the posterior end.

Staurocephalites eucharis is similar to *Staurocephalites mccallae* Eller (1945) except for the arrangement and number of the denticles and the curved or arched nature of the jaw.

Staurocephalites ejectus sp. nov.

Maxilla II. Plate 1, Fig. 15-17

Because of the broken margins of the two attached jaws the true shape is not discernible. Its form in general is wide and elongate. A jaw that is probably nearly complete in length measures 1.32 mm. Along the inner margin of the larger jaw a series of about fourteen conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. The denticles are oblique to the plane of the jaw. The area adjacent to the denticles is flat or slightly concave when observed from the under side. The outer margins are irregular and broken. A large fossa occupies the upper side of the jaw. Attached to the anterior end is a secondary jaw. When observed from the under side no line of articulation can be detected. The jaws seem to be cohered. Along the curved outer margin of the secondary jaw a series of about twelve conical, sharp-pointed, backward-directed denticles extends the full length of the jaw.

A number of species of *Staurocephalites* are similar to *Staurocephalites ejectus* especially in the presence of a secondary jaw. *Staurocephalites appositus* Eller (1945), *Staurocephalites aeguilateralis* Eller (1955), *Staurocephalites triplus* Eller (1945) and *Staurocephalites divinctus* Eller (1946) consist of two jaws in which it is difficult to find a suture or line of articulation. *Staurocephalites ejectus* differs from these forms mainly in that the second jaw is at the anterior instead of at the side and that it is much larger.

Genus MARLENEITES Eller, 1945

Marleneites elatus sp. nov.

Maxilla II. Plate 1, Fig. 11-12

In outline the jaw is irregularly elongate. The figured specimen measures 0.57 mm. in length and 0.12 mm. in width at the anterior and 0.2 mm. near

the posterior. On the convex under surface or inner margin a series of 11 or 12 sharp, conical, backward-directed denticles extends the full length of the slightly arched jaw. The first denticle is large and separated from the next denticle by a small space. The remaining denticles are closely spaced and uniform in size except at the posterior end where they become smaller. The anterior end of the jaw is rounded and slightly concave adjacent to the denticles and the high, thick, rounded margin. The outer margins are irregularly curved and are thickened. A wide area or flange is present on the left outer side at the posterior area of the jaw. A large fossa occupies the complete upper side of the jaw.

Marleneites elatus is similar to other forms of this genus. It differs mostly in the shape of the jaw, the width of the posterior end and the size of the first denticle.

Marleneites explicatus sp. nov.

Maxilla II. Plate 1, Fig. 13-14, 19

The jaw is elongate and large and the figured specimens measure from 1.22 mm. to slightly more than 1.32 mm. in length. On the lower surface or inner margin a series of 10 to 12 large, conical, pointed denticles extends the full length of the jaw. The first denticle is slightly larger than the second. Anteriorly the denticles are large and widely spread out but posteriorly they become small and close together. In some specimens the denticles are slightly oblique to the plane of the jaw. Adjacent to the denticles there is a slight convexity. The anterior of the jaw is broadly rounded while the posterior is narrow. A thickened margin is present at the anterior which would also be true of the outer margins if they were complete. A deep fossa occupies the upper side of the jaw.

Marleneites explicatus is similar to *Marleneites aureus* Eller (1945) except for the size and number of denticles, the width of the jaw and the depth of the fossa.

Genus *Ildraites* Eller, 1936

Ildraites eminulus sp. nov.

Maxilla II. Plate 1, Fig. 18

In outline the jaw is large and subtriangular. The figured specimen measures 1.35 mm. in length and 0.77 mm. in width. Along the curved inner margin a series of 11 large, conical denticles extends nearly to the posterior end. The first denticle or fang is large, thick and perpendicular to the inner margin. It is followed by two small, rounded teeth. The remaining denticles are large and projected a little outward and are backward directed. They decrease in size gradually to the posterior. The outer margin incurves slightly to a medium sized, sharp-pointed shank. A fairly deep crescent-shaped bight on the outer margin forms the curved posterior margin of the shank. About one-half of the outer side of the jaw is occupied by a narrow but deep fossa. The margins of the fossa are thickened and rounded.

In the outline *Ildraites eminulus* is similar to *Ildraites howelli* Eller (1941). They differ in the number and character of the denticles, the width of the jaw and the shape of the bight. Hinde (1882) described a species, *Arabellites anglicus* Hinde, that is similar in shape but differs in the number, size and shape of the denticles and the opening of the fossa.

Genus *Nereidavus* Grinnell, 1877*Nereidavus exploratus* sp. nov.

Maxilla I, II. Plate 1, Fig. 20-21

The jaw apparatus consists of a Maxilla I and II. They are probably not in an exact natural position. Maxilla I is large, elongate, and measures 1.90 mm. in length. Along the inner margin a series of 11 small, rounded denticles occupy about 0.65 mm. of the length. The denticles are backward directed and nearly uniform in size. A large, thick fang is at right angles with the nearly straight inner margin. The outer margin is incurved slightly but is generally parallel to the inner margin. Present at the posterior end is an irregularly shaped bight. Its margin curves to the inner margin of the jaw to form an acute posterior extremity. A large, deep fossa is present on the upper side of the jaw. The margins of the fossa are slightly thickened. The anterior margin of the fossa continues to the outer margin of the jaw to form a small shank. Both the upper and under surfaces of the jaw are irregular. Maxilla II is subtriangular in outline. It measures 1.42 mm. in length and 0.82 mm. in width. A series of 11 large, conical, backward-directed denticles extends nearly the full length of the slightly curved inner margin. The denticles are not uniform in size or arrangement. The first two denticles are small while the third is large and thick. This is followed by a smaller tooth. The succeeding denticles are large, conical and pointed except for the last two which are small and rounded. The anterior margin is slightly incurved and terminates in a narrow and pointed shank which also emphasizes the narrowness of the shank. The fossa is narrow and deep, and extends from the end of the shank to the posterior extremity. The margins of the fossa are thick and well rounded.

Nereidavus exploratus is similar to many species of *Nereidavus*. It is quite like *Nereidavus harbisonae* Eller (1941) but differs in the character and arrangement of the denticles and the shape of the fossa. Lange (1947) described a new genus, *Paulinites*, for articulated forms very similar to *Nereidavus exploratus*. There does not seem to be any valid reason for a new genus since Grinnell (1877) erected the genus *Nereidavus* which includes species of this type. The fact that additional parts to the jaw apparatus have been found in articulation does not invalidate a genus that was erected 70 years before. Many parts of fossil plants and animals have been described separately under various genera before a complete form has been found. The first described genus rates priority.

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EXPLANATION OF PLATE I

Figures magnified about 28 times.

Numbers in parenthesis indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1. *Eunicites effusus* sp. nov.
Maxilla IV, right jaw (28705).
Under side.
Dundee, Michigan.
- Fig. 2. *Eunicites extentus* sp. nov.
Maxilla IV, right jaw (28706).
Upper side.
Sibley Quarry, Trenton, Michigan.
- Fig. 3. *Eunicites extentus* sp. nov.
Maxilla IV, left jaw (28707).
Under side.
Dundee, Michigan.
- Fig. 4. *Eunicites extentus* sp. nov.
Maxilla IV, right jaw (28708).
Upper side.
Sibley Quarry, Trenton, Michigan.
- Fig. 5. *Eunicites euconus* sp. nov.
Maxilla IV, right jaw (28709).
Upper side.
Dundee, Michigan.
- Fig. 6. *Eunicites* ? sp.
Maxilla IV, left jaw (28710).
Under side.
Dundee, Michigan.
- Fig. 7-8. *Paleoenonites exsertus* sp. nov.
Maxilla II, left jaw (28714).
Upper and under sides.
Dundee, Michigan.



- Fig. 9. *Paleoenonites editus* sp. nov.
Maxilla II, right jaw (28715).
Upper side.
Sibley Quarry, Trenton, Michigan.
- Fig. 10. *Staurocephalites eucharis* sp. nov.
Maxilla II, right jaw (28716).
Under side.
Sibley Quarry, Trenton, Michigan.
- Fig. 11-12. *Marleneites elatus* sp. nov.
Maxilla II, left jaw (28717).
Under and upper sides.
Sibley Quarry, Trenton, Michigan.
- Fig. 13-14. *Marleneites explicatus* sp. nov.
Maxilla II, right jaw (28719).
Lateral and upper sides.
Dundee, Michigan.
- Fig. 15. *Staurocephalites ejectus* sp. nov.
Maxilla II, right jaw (28721).
Under side.
Sibley Quarry, Trenton, Michigan.
- Fig. 16-17. *Staurocephalites ejectus* sp. nov.
Maxilla II, right jaw (28723).
Upper and under sides.
Dundee, Michigan.
- Fig. 18. *Ildraites eminulus* sp. nov.
Maxilla II, right jaw (28724).
Upper side.
Sibley Quarry, Trenton, Michigan.
- Fig. 19. *Marleneites explicatus* sp. nov.
Maxilla II, right jaw (28725).
Under side.
Dundee, Michigan.
- Fig. 20-21. *Nereidavus exploratus* sp. nov.
Maxilla I, left jaw (28727).
Upper and under sides.
Dundee, Michigan.

ART. 16. REPORTS ON THE MARGARET M. CARY AND
CARNEGIE MUSEUM EXPEDITION TO
BAJA CALIFORNIA, MEXICO, 1961

1. Introduction. Itinerary and Localities

BY RICHARD M. FOX

Associate Curator, Section of Insects and Spiders

An expedition to Baja California, Mexico, was fielded during the autumn of 1961 under the sponsorship of Carnegie Museum through the generosity of Margaret M. Carey. As long as I have known her—and that has been since my youth—she has occupied a very special place in my affections. Her sincere, enthusiastic fascination with the marvels of nature has been expressed in so many ways through the years: the proteges who became competent in the sciences because of her encouragement, her leadership in and support of conservation, her interest in research, her own work as a lepidopterist, to name a few. One hesitates to refer to her as an “amateur” scientist; certainly her own publications in the zoögeography and systematics of the family Sphingidae have been of “professional” caliber.

The object of the trip was to obtain a maximal sampling of the insect fauna, both diurnal and nocturnal, with special emphasis on the Sphingidae, as well as herpetological specimens, in as many different ecological situations as possible. The principal geographic objective was that part of the peninsula southward from La Paz. As leader of the expedition, I tried to plan the details of our field work in such a way that not only would Carnegie Museum benefit from the specimens brought back, but that our efforts and the possible scientific results to be obtained from them would supplement rather than compete with other scientific groups interested in Baja California.

The field staff included five entomologists and Neil D. Richmond, Curator of Amphibians and Reptiles. The entomologists—Jean W. Fox, Harry K. Clench, John G. Bauer and Lee D. Miller are all associated with the Section of Insects and Spiders.

The expedition was in the field from October 16 until December 11. After final staging in San Diego, Richmond, Clench and Bauer left Tijuana, Baja California Norte, on October 16 and proceeded south on the eastern side of the Gulf of California in the expedition vehicle. The purpose of this party was to obtain material, especially Sphingidae, for comparison with the peninsular fauna. They crossed from Mazatlan, Sinaloa, to La Paz, Baja California Sur, by air on November 4, the vehicle and equipment following by sea and arriving on November 9.

Meanwhile the Foxes and Miller had proceeded by air directly to La Paz, arriving on October 17. Using a taxi for transportation, this party collected extensively in the lower part of the peninsula between La Paz and Cabo San Lucas.

On November 13 Richmond, Clench, Bauer and Miller proceeded by pack-train into the Sierra de la Laguna from the village of Boca de la Sierra, returning on November 18. During this week the Foxes were based at Bahía de Palmas and worked the region between Arroyo San Bartolo and Miraflores.

From November 21 to 27 Richmond and Miller were based at Puerto

Chilena while Clench and Bauer worked out of San José del Cabo and where I joined them on November 24. Jean Fox worked out of La Paz during this time.

On December 3 the expedition vehicle with Richmond, Clench and Miller on board left La Paz and, driving north along the peninsula, reached Tijuana on December 10. The Foxes and Bauer, after further collecting in and near La Paz, flew to Tijuana on December 8.

The insect collections made were quite large. As they can be prepared and submitted to specialists, it is expected that the scientific results will be published in this series of papers.

Everyone everywhere was co-operative and friendly; we received so much kind assistance that it is impossible to give credit to all the people who contributed to the success and comfort of the expedition. Special thanks are due to Dr. George E. Lindsey, Director of the San Diego Natural History Museum; to Señor Eduardo Manriquez, our taxi driver; to Señor Antonio Pereda, manager of the Guaycura Hotel in La Paz; to Señor Juan Mitri and Señor Jorge Escudero, of the Hotel Bahia de Palmas.

LOCALITIES

A great deal has been written about Baja California, both by travelers and by scientists. A short list of some of the titles in both categories is appended, but no attempt is made here to present a detailed ecological account of the region.

The peninsula of Baja California is the extreme southwestern extension of the great Sonoran Desert. It is surprisingly diverse, however, and very little of it is identical with, say, Arizona and New Mexico. Much of it is hilly or mountainous, rugged, cut with deep gorges which become wide, sandy, dry river beds as they near the sea. Rain is a rarity in nearly all of the region. Between Cabo San Lucas and Todos Santos, there had been no rain at all for several years before our visit. But the higher mountains receive, in some cases, quite ample moisture. The Sierra de la Laguna is one of these, part of a high mountainous plateau which extends from a little south of La Paz nearly to Cabo San Lucas. It has several peaks well over 6000 feet; there are some lakes and permanent streams, and oak and pine forests at the upper levels. All around the base of this plateau, springs and the mountain streams, dammed before they disappear into the deeply sandy lower reaches of the arroyos, make oases of productive agriculture possible, and limited areas sometimes lush. Farther to the north, in the Santo Domingo region, deep wells tap a water reservoir said to be entrapped by a volcanic shield, and rich crops of wheat and cotton are produced.

Irrigated places are natural insect traps, apparently attracting the fauna from the vicinity and concentrating it within a small area. Similarly, the carefully tended, richly blooming plantings around some of the hotels make excellent sites for collecting. The field parties worked all such places found, as well as the more natural situations where the wild vegetation was green because of a recent shower or because of favorable underground water. In addition, the arid hill slopes, the more or less burned out arroyos and dry fields, were worked over to find the species (and there are some) which per-versely prefer such places.

It is hoped that the various specialists who study our collection will detail the faunal relationships they find. The species inhabiting the southern part of the peninsula may be expected to fall into five categories: 1. The very widely distributed species found throughout the peninsula, on the mainland and in Southern California. 2. Species inhabiting the peninsula and also found in Southern California but not on the Mexican mainland. 3. Species, generally representing a tropical affinity, present on the mainland and on the southern part of the peninsula, but not in the more northerly part or in Southern California. 4. Indigenous subspecies which as species fall into one of the previous three categories. 5. Inhabitants of the upper levels of the Sierras, some of which may prove to be indigenous species or subspecies but with clearly temperate affinities.

In the following list, the localities visited by members of the expedition are given first for Baja California Sur, then for Baja California Norte, for Sonora, and for Sinaloa. The list for each state is arranged alphabetically. Many of the localities in Baja California Sur are numbered below, and the numbers appear on the map (Fig. 1). The localities in Sonora and Sinaloa are all expressed in terms of distance and direction from a major town readily found on any standard map, and in some cases latitude and longitude are given. Detailed information on the expedition, on all of these localities and, in most cases, the exact times and weather conditions prevailing during each visit, as well as photographs, are on file in Carnegie Museum in the Section of Insects and Spiders and are available to scientists interested in the collections.

Baja California Sur

Bahia de la Paz. Eastern shore (1). Six miles north of the city beyond the lighthouse where the shore-line is marked by mud and stone tidal flats; brackish lagoons with mangrove lie behind sand dunes. Inshore the terrain is arid desert.

Bahia de Palmas (13). A fishing hotel at the telegraph station of Los Bariles, placed on the sandy beach shelf about one-half mile wide with the sea to the east and low but rugged and dry hills to the west. The natural vegetation is sparse, with dune scrub on the beach, cactus and thorn inshore. The hotel grounds are well planted with cultivated species and attract a concentration of insects. The ultra-violet light trap was operated here for 12 nights; daytime work included collecting both on the hotel grounds and in the surrounding area of natural vegetation.

Boca de la Sierra (17). An agricultural village at the end of a branch "road" from Miraflores and at the beginning of the trail up the eastern slopes of the Sierra de la Laguna. Above the village, in Arroyo San Bernardo, the permanent stream is dammed and the water diverted to the farms of this community. The vegetation at the village is thick and green, as is that in the arroyo near the dam. The surrounding countryside is, of course, cactus and thorn scrub. Many collections were made during the daytime hours and the ultra-violet light trap was operated one night.

Buenavista (14). An arroyo crossing the main road 5 km. south of this hotel on the main road between La Paz and the cape. Basically arid and sandy, on October 25 it was found to be covered by grass, and shrubs were blooming, because of a recent rain.

Cabo San Lucas (24). The extreme southern tip of the peninsula where there is a small town centered around a cannery. The region is generally barren sand dunes and gravel flats with cactus-mesquite-ocotillo scrub back from the beach. The area was quite dry and a few miles northwest there had been no rain for several years.

Caduan (20). This village is located just to the east of the main north-south road about three miles south of Miraflores. The irrigated farm lands support a rich vegetation; the non-irrigated areas surrounding them are covered with a rather high, quite dense thorn and cactus jungle.

Candelaria. Arroyo (25). This very wide arroyo from the high slopes of the Sierra de la Laguna to the Pacific is one of the major watersheds in the district. Since there had been no rain for several years, the few farms depended on subsurface water and in general the area was dry to burned. One fairly narrow branch arroyo about six km. south of the main stream bed apparently bore good subsurface moisture and was lushly green both in October and in November.

El Carocol. This tiny community is 38 miles northwest of San Ignacio on the main road running north along the peninsula. The dry dunes and gravel bear a very sparse flora of desert types.

Chilos. Arroyo de los (10). A dry stream bed located between San Antonio and San Bartolo on the main road; it has enough subsurface water to support limited agriculture.

La Cienaga I (19). An open, grassy oak forest at 1270 meters above sea-level in the Sierra de la Laguna. A notice posted at this point states its position as 109° 57' 30" West and 23° 29' 30" North. Placed in a saddle of the mountains, ground vegetation included some large prickly pears, purple flowering mint and palms. This was the farthest advance of the pack trip party, which turned back here on November 15 because low temperatures were reducing collecting to the vanishing point.

Ensenada de Palmas. Rancho (12). A stock farm about 1½ miles north of Bahía de Palmas on the main road and not far from the sea. The mouth of a wide sandy arroyo lies along its northern edge, and to the south is a small mesa with steep walls. Behind the bluff and the irrigated ranch-house area is a large fenced range extending west toward the foot-hills of the mountains. The area is cactus and thorn scrub with a certain amount of grass in favorable places.

Hondo. Arroyo (8). A valley beginning near El Triunfo and running to the Pacific; not to be confused with the better known arroyo of the same name at Todos Santos. The road south from La Paz crosses this arroyo just before ascending into the mountains. About half a mile above the road crossing there is a dam and apparently permanent water, near which are willows and many flowering weeds including composites.

La Paz. Hotel Guaycura (4). Located on the paved road leading around the inner harbor from the city and about three km. from its center, about 1½ km. from the eastern margin of the inner harbor. The grounds are well planted in a profusion of cultivated plants and are constantly irrigated. The abundant blooms and lush vegetation attract a wide variety of insects and birds. The parties collected extensively on the grounds; the ultra-violet light

trap was operated there frequently. Open fields behind the hotel toward the airport were dry and weedy and yielded a rather different fauna. Material from these two areas is respectively recorded as "grounds" or "vicinity."

La Paz. An arroyo about 10 miles east of. Not far from Rancho Rosarito and Rancho El Salto and probably in the same arroyo system in the dry hills. It is wide and very sandy. The eastern bank is rocky and steep leading to the higher hills, but here and there are little grassy meadows. Vegetation is thorn scrub with fewer cacti.

La Paz Harbor. Southeastern shore of inner harbor (5). The inner harbor is referred to by local boatmen as "the lagoon." It is a wide, shallow bit of salt water margined by low dunes and brackish true lagoons with mangrove. *Avicinnia*-like mangrove was found in bloom during late November. Inshore there are wide marsh grass meadows beset with scrubby bushes.

Miraflores (16). A village at the foot of the Sierra de la Laguna on the motor road south of Santiago. Cultivated plants are present in the village and on the surrounding irrigated farms. The region between Miraflores and El Triunfo had received rain not long before the expedition visited it, so that much of the ground under the native cactus and thorn scrub was covered with grass and many different flowering herbs. Miraflores itself has wells and springs; it is locally renowned for its greenness.

El Novilla. Rancho (7). On a road branching east from the motor road at San Pedro, this is a palm oasis beside a dry, rocky arroyo. The irrigated area includes a little citrus orchard and many flowering plants. Wild fig grows along the arroyo and there are mesquite, cactus, and thorn.

Palmarita. Rancho (26). Located about 12 miles directly north from Todos Santos, some three or four miles from the Pacific coast and about six miles along a rough lane from the motor road. A spring in a limestone formation yields abundant water which is piped across the arroyo to the lush and well managed farm. In addition to a large stand of date palms, there are many varieties of citrus trees, mango, several hundred guava trees, and a rotation of field and vegetable crops. Many native plants thrive and bloom along the margin of the farm. The surrounding country is an arid jungle of cardon cactus. The lane to the farm passes through a spectacular stand where the cardon frequently reaches 40 feet and is shoulder to shoulder. The ultraviolet trap was operated here through three nights.

Poza Grande. About 25 miles north of Santo Domingo on the motor road from La Paz, located on the mesa just before the road enters Arroyo Comondú. A dry burned desert with cacti, yucca and elephant trees.

Puerta Azul. Mesa (9). A ranch lying on both sides of the motor road a few miles south of El Triunfo and just below the final ascent to the high pass toward San Antonio; about 2100 feet above sea level. Shortly before the expedition's visit, rain had caused a profusion of green vegetation. The ground was covered with grass and small herbs and everything was blooming. A month after the first visit, the area had reverted to dry desert.

Puerto Chileno (23). The new Hotel Cabo San Lucas, located on cliffs overlooking the sea near Cabo San Lucas, served as an operational base for part of the expedition in late November. The beach is rocky with few sandy stretches. Behind it the dunes bear grasses and low composites, and farther

inshore the country is dry mesquite-chollo-pitiaya desert broken by small arroyos. The ultra-violet light trap was operated through five nights.

Purisima, La. A large oasis with a substantial permanent stream and much of the valley under intense cultivation with dates, grapes, citrus fruits, guava, sugar-cane and corn. It lies in the wide bottom of an arroyo with steep walls among almost vegetationless hills. The ultra-violet trap was operated through one night.

Rincon. Arroyo El (21). This is a dry arroyo with some local irrigation. The surrounding country is flat and sandy, and has a scattering of large, old trees. The hilltops and slopes beside the arroyo are exceedingly arid with cacti predominant. The arroyo is an eastern branch of the large Arroyo San José, an important agricultural area. It is reached by turning off the main motor road on a well used side road to the east about six miles north of San José del Cabo.

Rosarito. Rancho (2). A small farm located about 10 miles due east of La Paz in the northern foot-hills of El Mulato peak at about 600 feet above sea-level. The area is dry desert scrub, deeply eroded with sand and gravel, and formations of huge rounded boulders.

Salto. Rancho El (6). Another small farm a few miles north of Rancho El Novilla and east of San Pedro. Here the arroyo has a silt dam holding back a trickle of water. An extensive stand of desert willow borders the stream bed.

San Bartolo. Arroyo (11). The motor road follows this arroyo south of San Antonio to the sea. The village of San Bartolo is located about 10 miles back from the coast at a point where a large arroyo from the Sierras joins the main stream. A high silted dam blocks the arroyo just below the village and diverts the water to agricultural uses. Farm land is limited by the very steep cañon walls, but is lush and green. Fruit crops and sugar-cane predominate. The surrounding hills are completely arid with sparse cactus and scrub. Below the dam the residual stream runs along a rocky bed and waters desert willows, local weeds and shrubs before disappearing into the sand. The ultra-violet trap was operated just above the dam during three different nights, and the collecting in the area was frequent during the day.

San Bernardo. Arroyo (18). A long valley with permanent water from the saddle at La Cienaga I (1270 meters) to Boca de la Sierra. Below the latter place, the water disappears in the sandy arroyo bottom. The greater length of the valley has very steep, dry and rocky sides. Frequent pools formed above huge boulders in the stream bed support a varied aquatic fauna and flora and their banks are green and often well grown. Willows, mesquite, wild fig and palms predominate at lower levels. Oaks are encountered at 250 to 300 meters altitude and open forest exists at about 750 meters. For the purpose of recording the collections, the arroyo was subdivided as follows:

From the dam near Boca de la Sierra to 490 meters, Lower Arroyo San Bernardo.

From 500 to 600 meters, "Rancho San Bernardo" after an abandoned farm at that level where the pack party spent the night.

From 600 meters to the crest of the trail at 1350 meters, "Rancho Agua Blanco" after an abandoned ranch near the saddle.

San Bruno. Fourteen miles south of Santa Rosalia on the main motor road. A blooming critola bush in the dunes along the Gulf attracted many insects.

San Isidro. A town about three miles east of La Purisima in the same arroyo and beside permanent water. A stop for collecting was made about $3\frac{1}{2}$ miles beyond the town along the road, and work was chiefly in and beside the stream, which runs over loose and bed rocks and has cattails and similar plants beside it.

San José del Cabo (22). This old, small city was an outfitting point for whalers many years ago but now is almost exclusively an agricultural center. Part of the expedition stayed here for a day in October and a few days during November. A little back from the beach south of the city there is a long fresh-water estuary surrounded by irrigated fields. The ultra-violet trap was operated in these fields for one night in October and for two nights in November.

Santiago. 3 km. south of. An arroyo crosses the road diagonally, its northern bank marked by high bluffs. Its bed is brown sandy soil rather than pure sand and is not very rocky. Predominant trees are palo verde and palo blanco mixed.

Torote. Rancho El. (15). This is the farm of Señor Filipe Morena, about five to seven miles east of Santiago, lightly irrigated in the bottoms. It is mostly dry desert mesa cut into small or medium arroyos, many of them deep, steep and narrow.

Vinarama. Rancho (3). A date palm oasis with springs and wells in an extremely dry desert area located about 10 miles due east of La Paz and about three miles south of Rancho Rosarito in the foot-hills of El Mulato Peak. The limited area under cultivation is fringed with desert willow.

Baja California Norte

Mexicali. 21 miles south of. $32^{\circ} 23'$ North, $115^{\circ} 20'$ West. An area of true Sonoran desert, chiefly low, widely spaced ocotillo, mesquite and chollo.

Bahia de San Luis Gonzaga. A bay on the Gulf coast about $29^{\circ} 50'$ North, where the northbound motor road first reaches the shore.

Sonora

Caborca. Two localities. One was about 10 miles northwest of the city ($30^{\circ} 45'$ North, $112^{\circ} 16'$ West); a saguaro, organ pipe and cholla association with flowering composites. The second locality was 40 miles to the east, also on the main motor road ($30^{\circ} 34'$ North, $111^{\circ} 28'$ West), in a series of very dry washes, the valley of the Rio de las Pexedras; a thick forest of mesquite-like trees with browned grass under foot.

Colorado River. Five miles west of Riito on the eastern bank of the river; grass and mesquite on muddy flats.

Cuidad Obregon. One locality was 22 miles west of the city ($27^{\circ} 37'$ North, $110^{\circ} 09'$ West). A second locality 11 miles southeast, also was on the motor road ($27^{\circ} 23'$ North, $109^{\circ} 52'$ West) in what seemed to be a plantation of agave.

Guaymas. A locality 36 miles north on the motor road ($28^{\circ} 10'$ North, 111° West) in a desert area with more grass than usual. A second locality 16 miles east ($27^{\circ} 57'$ North, $110^{\circ} 38'$ West) was an arroyo with standing

water in a dry desert area. A third locality 21 miles east ($27^{\circ} 54'$ North, $110^{\circ} 01'$ West) was another arroyo with standing water. Collecting was also done at the grounds and lights of a motel where the mainland party stopped overnight.

Hermosillo. Two localities. A motel where the party spent the night and collected both at lights and from the planted ground. A stop was made 12 miles south ($28^{\circ} 52'$ North, 111° West) in a dry arroyo with a broad sandy floor and numerous shrubs including a yellow-flowering composite.

Navojoa. Three localities. The motel where the party spent the night was not far distant from an arroyo with running water; grounds and lights were worked. A stop was made 16 miles south ($26^{\circ} 52'$ North, $109^{\circ} 23'$ West) in a desert with clumped vegetation including large prickly pear and agave. Another stop was made 39 miles south of the town ($26^{\circ} 24'$ North, $109^{\circ} 09'$ West) in an organ pipe, mesquite and prickly pear association with a few agaves present.

Pinacate Peak. 13 miles east of. A very dry series of arroyos with some palo verde trees on dark lava soils and rock.

Puerto Penasco. Four miles northeast of. At about $31^{\circ} 21'$ North, $113^{\circ} 32'$ West in low scrub desert with low dunes and salt bush.

San Luis. 10 miles east of. Some snakes found dead on the road while driving at night.

Santa Ana. 66 miles south of. A bull snake found dead on the road while driving at night.

Sonoyta. Three localities. Moths were found at the lights of a motel. A stop was made 10 miles southwest on Route 8 in a very dry mesquite desert ($32^{\circ} 42'$ North, $112^{\circ} 59'$ West). Another stop was made 25 miles southwest at $31^{\circ} 43'$ North, $113^{\circ} 14'$ West.

Sinaloa

Concordia. Various stations in the vicinity of. A stop was made 19 miles northeast at 730 meters above sea-level ($23^{\circ} 23'$ North, $105^{\circ} 55'$ West) in the western foot-hills of the mountains where the country is very steep with luxuriant vegetation including *Poinsettia*, wild cosmos and marigold.

A dry open oak grove in a saddle of the mountains at 890 meters about 22 miles northeast of the city was visited ($23^{\circ} 23'$ North, $105^{\circ} 52'$ West).

An open forest of long-needed pine trees with trunks six to eight inches in diameter, widely spaced with little underbrush but with grass and sparse herbs; 26 miles northeast of the city at 1130 meters ($25^{\circ} 22'$ North, $105^{\circ} 52'$ West).

A dry arroyo with a little standing water about two miles east of the city.

The lower levels of the mountains, about 570 meters, 17 miles northeast of the city and not far from Santa Lucia; lush vegetation on steep slopes.

A point three miles east of the city on the road, well out of the mountains.

The roadside about eight miles west of the city in well vegetated low hilly country with the shoulders of the road weedy.

A moderately hilly area, partly farmed and partly forested with high brush and open scrub about five miles southwest of the city.

Culiacan. 48 miles northwest of. A dry arroyo mostly open but with shaded areas (25° 18' North, 107° 56' West); mixed forest with large prickly pears and organ-pipe cactus intermingled; dubbed "butterfly gulch" by the mainland party.

Los Mochis. Collecting was done in three localities near this town. One, just two miles south of the state line and about 46 miles north of the town (26° 22' North, 109° 00' West), was characteristic mesquite scrub in an arroyo with standing water. Another, 19 miles north of Los Mochis on the motor road, was the dry shoulder of a low hill. The third was 10 miles southeast (25° 47' North, 108° 52' West) on tidal flats near irrigated farms, locally with dense mesquite scrub, tall prickly pears and organ-pipe cactus.

Mazatlan. Flamingo Hotel. The mainland party was based here for 11 days and collected moths at the lights and diurnal insects on the richly planted grounds.

Mazatlan. Localities near. Collecting was done in seven localities. Some purple morning-glories growing beside the road four miles to the southeast.

Fields behind the beach just north of the city; a highly disturbed area with low vegetation, many sand spurs, some heavily grayed mesquites forming scrub patches, some organ-pipe cacti, morning-glory tangles and sugar-cane.

Rocky hills about three miles north of the city where morning-glories and other low forms flowered among mesquite scrub.

Beside the road about 11 miles north where large masses of a small yellow-orange composite and tall sunflower-like weeds were found in flower.

Along a dirt road passing through a fairly dense woods with cactus, mesquite, trees, and ground cover, about 16 miles north of the city.

About 18 miles north of the city and three miles west along a side road in rather dense thorn scrub woods with agave-like plants on one side of the road, open fields on the other, in gently rolling country.

The sandy flats at the southern edge of the city with burrs and beach morning-glory.

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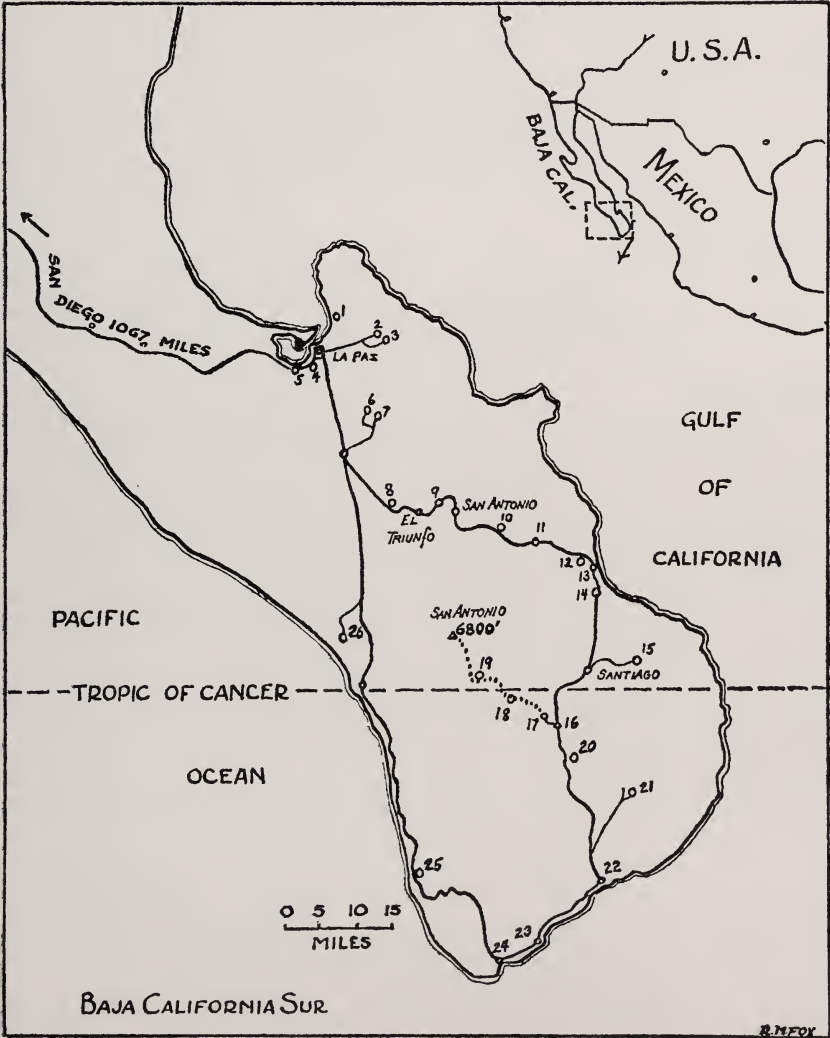
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Continued on page 192

Fif. 1. Map of southern part of Baja California peninsula. Collecting sites numbered. See text for description of localities. 1. Eastern shore of Bahía de La Paz. 2. Rancho Rosarito. 3. Rancho Vinarama. 4. Hotel Guaycura, La Paz. 5. Southeastern shore of inner harbor, La Paz. 6. Rancho El Salto. 7. Rancho El Novilla. 8. Arroyo Hondo. 9. Mesa Puerta Azul. 10. Arroyo de los Chilos. 11. Arroyo San Bartolo. 12. Rancho Ensenada de Palmas. 13. Bahía de Palmas. 14. Five km. south of Buenavista. 15. Rancho El Torote. 16. Miraflores. 17. Boca de la Sierra. 18. Arroyo San Bernardo. 19. La Cienaga I. 20. Caduano. 21. Arroyo El Rincon. 22. San José del Cabo. 23. Puerto Chileno. 24. Cabo San Lucas. 25. Arroyo Candelaria. 26. Rancho Palmarito



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ART. 17. REPORTS ON THE MARGARET M. CARY AND
 CARNEGIE MUSEUM EXPEDITION TO
 BAJA CALIFORNIA, MEXICO, 1961

2. The Family Sphingidae (Lepidoptera)

MARGARET M. CARY, Philadelphia, Pa.

[This is the second of a series of papers based on the Margaret M. Cary and Carnegie Museum Expedition to Baja California, Mexico. For an account of the itinerary and description of the localities, see the first paper in this series by Richard M. Fox, Art. 16 in *Annals of Carnegie Museum*, v. 36, pages 181 to 192. Except as noted, all specimens including type series are in the collection of Carnegie Museum.]

The family Sphingidae in Baja California has never before been studied. The present paper deals only with the collections made by the 1961 expedition, mostly by use of moth traps fitted with ultra-violet light (to be described in another paper). When collections are completed for the entire peninsula, the total number of species represented probably will be several times the number listed here. The expedition was in the field during October and November. Nothing is yet known of the sphingid fauna of the spring or summer months.

The expedition brought back 282 sphingids representing 18 species, of which 244 specimens of 14 species were taken on the peninsula. Eight of the species taken in Baja California are widely distributed and occur both in the United States to the north and on the Mexican mainland to the east with no geographic variation. Of the others, *Pachylia syces* is tropical, found on mainland Mexico but not in Western United States, but on the other hand, *Smerinthus cerisy ophthalmica* is a temperate element long known from southern California. It is interesting to find that its range extends to the very tip of the peninsula. The subspecies from the mainland of Mexico is *S. c. saliciti* Boisduval. Our mainland party found four species not taken on Baja California. Two of them are represented there by closely related species but the other two so far are not known to cross the Gulf.

Four new endemic forms were found in Baja California and these are described below. One is a subspecies of the widely distributed *Phlegethontius rusticus*. One is a southern subspecies of *Pachysphinx modesta*, a temperate element. The other two are tropical representatives, one a subspecies of *Hemeroplanes parce*, the other a new species of *Sphinx* which apparently replaces *S. istar*.

The zoögeographic affinities of the sphingids obtained from Baja California Sur are summarized as follows:

Tropical distribution:	3 species of which 2 are endemic.
Temperate distribution:	2 species of which 1 is endemic.
General distribution:	9 species of which 1 is endemic.

Phlegethontius sextus sextus Johannson, 1763.

The specimens found on the peninsula do not differ from those found from Canada to Honduras.

Baja California Sur: La Purisima, 6♂ 3-xii. Guaycura Hotel, La Paz, 1♂ 20-x, 1♂ 22-x, 1♀ 29-x, 1♀ 31-x (In Cary collection), 2♂ 6-xi, 1♀ 29-xi, 2♂ 4-xii. Bahia de Palmas, 4♂ 2-xi, 2♂ 12-xi, 1♂ 15-xi, 2♂ 17-xi (1 in Cary

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collection), 1 ♂ 1 ♀ 20-xi. Boca de la Sierra, 1 ♀ 17-xi. Rancho Palmarito, 1 ♂ 20-x, 1 ♂ 4-xi. Puerto Chilena, 1 ♀ 23-xi, 1 ♀ 26-xi. San José del Cabo, 2 ♂, 25-x.

Sonora: Guaymas, 1 ♂ 20-x.

Sinaloa: Five miles west of Concordia, 1 ♀ 28-x. 16 miles north of Mazatlan, 3 ♂ 2-xi.

Phlegethontius quinque maculatus Harris, 1803.

The two males and one female taken are identical with specimens from the mainland, both in Mexico and throughout the United States.

Baja California Sur: Hotel Guaycura, La Paz, 1 ♂ 28-x. Bahía de Palmas, 1 ♂ 1 ♀ 20-x.

Phlegethontius rusticus cortesi subsp. nov. (Fig. 1.)

Specimens from Baja California are somewhat smaller than mainland specimens. Average fore wing length of Mexican *rusticus* (Fig. 2) is 130 mm., average fore wing length of *cortesi* 85 mm., though two of the series had a length of 110 mm. In comparing the series from the peninsula with specimens from the mainland, one is struck not only with the smaller size of Baja specimens, but especially with their pepper and salt black-and-white coloring, in strong contrast with the brown-and-white coloring of mainland specimens. In the West Indies *P. rusticus* is subject to insular subspeciation, with *P. r. cubanus* on Cuba, *P. r. dominicanus* on Hispaniola and *P. r. harterti* in the Windward Islands. Thus although mainland specimens are *P. r. rusticus*, it is not surprising to find still another subspecies on Baja California.

Antennae brown with white above in mainland specimens, but grayish black with white above in those from Baja. In both they are set in white but the white is more extensive in *r. cortesi*, forming a narrow band on top of the head. Thorax of *cortesi* has much white mixed with dark gray, while the thorax of *r. rusticus* is uniform brown. Both have white where the wings join the thorax, but in *cortesi* there is a black line above the white. The white spots on the abdomen above are very bright on *cortesi*, but are missing in mainland specimens. Both forms have a dark medial line on the dorsum and the ventral side is white with five dark spots.

The white transverse area bounded by a black zigzag line at the apex of the fore wing in *cortesi* is much less clearly defined in *r. rusticus*. On the hind wing above, mainland specimens are almost solidly brown with two white lines basad at the anal angle. In *cortesi* there are three distinct white lines, the upper of which becomes a white spot at the anal angle, the median line runs from the costal to the inner margin; these two are barely indicated in *r. rusticus*, with only the third line at all clear.

Under side of fore wing grayish black in *cortesi*, uninterrupted brown in *r. rusticus* from the mainland. A clearly marked grayish white band with a blackish pointed line at each edge in *cortesi* extends from the costal to the inner margin; this marking is scarcely indicated in mainland specimens. The hind wings beneath in both subspecies have two curving lines with many points running from the costal around to the inner margin; in *cortesi* this is black on white, but in mainland *rusticus* it is brown on white, though giving a sharper contrast than in *cortesi*.

Fringes black with white spots; in *cortesi* the white spots are prominent, but in *rusticus* they are small and insignificant.

Male genitalia: Essentially similar to typical *rusticus*, but with some minor differences noted: the valve of *cortesi* (Fig. 12) is somewhat narrower and its



Fig. 1. *Phlegethontius rusticus cortesi* subsp. nov., holotype ♂, San José del Cabo, Baja California. Upper side (left), under side (right)



Fig. 2. *Phlegethontius rusticus rusticus* (Fabricius), male from Misantla, Mexico, in Carnegie Museum. Upper side (left), under side (right)

tip a little more acute; in *rusticus* (Fig. 13) the wider valve has a more rounded tip. The sclerotization at the base of the dorsal margin of the valve, near the articulation, forms an in-pointing angled tooth in typical *rustica*, but this structure is evenly curved in *cortesi*. Some differences in the little projection at the ventral inner side of the valve may be noted in the figure, but this was found not to be a consistent variation in all preparations.

Six ♂, 2 ♀, all taken in the ultra-violet light trap.

Holotype ♂, San José del Cabo, Baja California Sur, Mexico; 26 November 1961; (genitalia slide 965).

Paratypes: Rancho Palmarito, 1 ♂ 30-x (genitalia slide 964). Bahía de Palmas, 3 ♂ 1 ♀ 12-xi (♂ and ♀ in Cary collection). Puerto Chilena, 1 ♂ 24-xi, 1 ♀ 25-xi.

This subspecies is named for Hernando Cortes who landed at La Paz in 1535.

Sphinx merops Boisduval, 1870.

Two males were captured by the mainland party in Sinaloa. This species is tropical, distributed from Mexico to Ecuador, but was not taken on Baja California.

Sinaloa: Five miles west of Concordia, 2 ♂ 2-xi.

Sphinx xantus sp. nov. (Fig. 3.)

S. xantus is smaller than the closely related *Sphinx istar* Rothschild and Jordan (Fig. 4), found on the mainland of Mexico, having the fore wing 90 mm. long compared to an average of 125 mm. for *istar*. *S. xantus* is more somber brown than the lighter, rather more variegated *istar*. A strong pinkish tinge in the median area of the fore wing of *xantus* contrasts with a similar whitish gray area in *istar*. These are the most easily noted differences between the two species.

In both species the antennae are medium brown above, white beneath in fresh specimens, and the antennal setae are brown; the head beside the base of the antennae, the top of the head and the palpi are gray; eyes and surrounding area black with a strong black interrupted line extending from the palpi to the base of the wing beneath; thorax gray above lined with a heavy black streak edged white at the wing base. Abdomens similar above, but the black medial line is more clearly indicated in *xantus* because the background is lighter than in *istar*.

Fore wing of *xantus* with four distinct white spots on the costal margin, these indicated only faintly in *istar*. Apex more whitish in *xantus* and the three dark brown lines from the apex are marked more sharply in *xantus* than in *istar*. Disk much darker brown in *xantus* and contrasts much more than in *istar*. Inner margins are light gray in both.

Hind wing with a black marginal band proportionately wider in *xantus* and the black median line proportionately narrower. The white median band in *istar* is penetrated by black tooth-like lines which are not present in *xantus*.

On the under side the fore wing of *xantus* is gray black and has only very indistinct markings; in *istar* this surface is a light brownish gray and is quite clearly marked by two heavy brown lines with white suffusion distad curving from the costa to the inner margin.

Hind wing beneath is also much darker in *xantus*. The two dark brown lines from the costal to the inner margin have in *istar* teeth intruding into the white band; in *xantus* the bands are narrower, set closer together, and have fewer denticular intrusions into the white. The marginal blackish gray band is wider in *xantus* than in *istar*.

Fringes of both species are brown and white but are brighter in *istar*.

Male genitalia (Fig. 14-18): The most striking feature is the harpogne, which bears numerous teeth distributed along the whole of its dorsal margin and set rather closely. In *S. istar* there are fewer of these teeth; they are not so closely placed and are mostly confined to the posterior half of the dorsal margin, the anterior part being undulate rather than toothed. The penis of *xantus* is about 10% longer (the valve is 60% of penis length) than that of *istar* (where the valve is 70% of the penis length). Fig. 14 shows the entire genitalia of the holotype (slide 956); dentition of the harpogne of the holotype is shown in Fig. 15, of the paratype in Fig. 16 (slide 957), of two males of *istar* in Carnegie Museum from mainland Mexico in Fig. 17 and 18 (slides 958 and 959).



Fig. 3. *Sphinx xantus* sp. nov., holotype ♂, San José del Cabo, Baja California. Upper side (left), under side (right)



Fig. 4. *Sphinx istar* Rothschild and Jordan, male from Misantla, Mexico, in Carnegie Museum. Upper side (left), and under side (right)

Two ♂'s, 1 ♀, captured at ultra-violet light.

Holotype ♂, San José del Cabo, 26 November 1961 (genitalia slide 956).

Paratype ♂, San José del Cabo, 25 November 1961 (genitalia slide 957).

Paratype ♀, Bahía de Palmas, 27 November 1961.

This interesting species is named for Janos Xantus (1825-1894), a native of Budapest, who made collections at Cabo San Lucas, Baja California, from August 1859 through February 1860. His extensive material was studied and published a century ago by the Academy of Sciences of Philadelphia and by the Smithsonian Institution. It seems fitting to dedicate this species to one of the pioneer naturalists to explore the lower peninsula.

Smerinthus cerisy ophthalmica Boisduval, 1855.

It is most interesting to find that this southern California subspecies extends its range along the peninsula and that it appears to be commoner in the mountains. *S. c. saliciti* is found in Arizona and the Mexican highlands and with the series of *ophthalmica* taken by the expedition marks the southern limits of this characteristically temperate species.

Baja California Sur: Arroyo San Bartolo, 4 ♀ 1-xi (one in Cary collection). Arroyo San Bernardo, 500-600 meters above sea-level in Sierra de la Laguna, 6 ♀ 17-xi (three in Cary collection). Puerto Chileno, 1 ♀ 26-xi.

Pachysphinx modesta peninsularis subsp. nov. (Fig 5.)

This subspecies represents the other essentially temperate species found in Baja California. Draudt gives "Colorado, Sonora and Lower California" as the distribution of the very pale *P. m. kunzei* Rothschild and Jordan, on the strength of which we expected to find it on the peninsula. It was not taken, however, and all specimens of *kunzei* in Carnegie Museum are from the United States. Instead and to our surprise, we found that Baja California has an endemic subspecies hitherto unrecorded. The geographically adjacent subspecies of *modesta* are *m. regalis* (Fig. 6) of the Mexican mainland, and *m. imperator* (Fig. 7) from Arizona, New Mexico and southern California. Baja specimens are slightly smaller than either:

<i>P. modesta regalis</i>	140 mm.
<i>P. modesta imperator</i>	125 mm.
<i>P. modesta peninsularis</i>	120 mm.

The fore wings of *regalis* are reddish and clearly marked, those of *imperator* a light creamy tan, while in *peninsularis* the wings are darker, less clearly marked and of a more uniform grayish tan. The wide, light brown band crossing the middle of the fore wing from the costal to the inner margin is indicated only weakly in *peninsularis* by the darker brown, scalloped outer edge. In *regalis* and *imperator* this whole band is dark brown and the scalloped distal edging is wider, though not as dark. In *regalis* there is a sharp point from the light brown area near the base of the wing reaching into the dark brown stripe over the anal vein; this point in *peninsularis* is weak and only poorly indicated. In *peninsularis* and *regalis* the marginal band is light grayish brown, less distinct than in *imperator*. Near the base of the wing is a curving brown line from the costal to the inner margin, barely indicated in *peninsularis* but strongly marked in the other two.

The upper side of the hind wing in both *regalis* and *imperator* is largely a rosy pink, deeper at the base. In *peninsularis* this coloring is grayish magenta and reaches the outer margin where it is only slightly lightened; in *regalis* the pink is limited by a light creamy border. In the anal angle of *regalis* there are three dark streaks, the first two very plainly marked and the third indicated. In *imperator* there are only the two strong streaks. In *peninsularis* the middle of the three streaks is present, merging into a gray area which runs to the anal angle and in which is a very shadowy second line.

Except for a magenta wedge at the base of the fore wing, the under side of *peninsularis* is almost uniform tan with only a slightly darker band on the outer edge. The under side of *regalis* is rosy pink and the band on the outer edge is more distinct. The under side of *imperator* is quite light, fairly uniform in color and poorly marked, like that of *peninsularis*.

In summary, *imperator* from California is much lighter, *regalis* from mainland Mexico is more strongly marked. These features, along with the magenta coloring of the hind wing of *peninsularis* as compared to the rosy pink of both *regalis* and *imperator* distinguish the Baja California subspecies.

Holotype ♀ and 2 ♀ paratypes, San José del Cabo, 25 October 1961, (one paratype in Cary collection), all taken at ultra-violet light.

Erinnyis ello Linne, 1758.

This is another common, very widely distributed species found throughout the Americas.

Baja California Sur: Hotel Guaycura, La Paz, 1 ♀ 17-x, 1 ♀ 18-x, 7 ♂ 1 ♀ 20-x (1 ♂ in Cary collection) 3 ♂ 4 ♀ 21-x (1 ♀ in Cary collection), 2 ♂ 23-x,



Fig. 5. *Pachysphinx modesta peninsularis* subsp. nov., holotype ♀, San José del Cabo, Baja California. Upper side (left), under side (right)



Fig. 6. *Pachysphinx modesta regalis* Rothschild and Jordan, female from Mexico, in Carnegie Museum. Upper side



Fig. 7. *Pachysphinx modesta imperiator* Strecker, female from Los Angeles, California, in Carnegie Museum. Upper side

1 ♀ 24-x, 1 ♂ 1 ♀ 26-x, 1 ♀ 29-x, 1 ♀ 6-xi, 1 ♀ 7-xi, 1 ♂ 30-xi, 1 ♂ 3-xii. Bahia de Palmas, 1 ♂ 12-xi. Rancho San Bernardo, 1 ♀ 17-xi. San José del Cabo, 1 ♂ 2 ♀ 25-x. Puerto Chilena, 1 ♀ 22-xi, 1 ♂ 23-xi. All taken at ultra-violet light.

Sinaloa: Sonoyta, 1 ♀ 18-x at motel lights. Guaymas, 3 ♂ 5 ♀ 20-x at motel lights.

Erinnyis yucatanica Druce, 1888.

A tropical species found in Costa Rica to Mexico on the mainland, it was not taken on the peninsula.

Sinaloa: Flamingo Motel, Mazatlan, 2 ♀ 2-xi, at lights.

Erinnyis obscura Fabricius, 1775.

The series from Baja California entirely agrees with mainland specimens of this tropical species.

Baja California Sur: La Purisima, 1 ♂ 3-xii. Hotel Guaycura, La Paz, 2 ♀ 27-x (1 in Cary collection), 1 ♂ 31-x, 1 ♂ 5-xi 1 ♂ 6-xi, 1 ♂ 29-xi, 1 ♂ 30-xi (Cary collection), 1 ♂ 3-xii. Bahia de Palmas, 1 ♂ 17-xi, 1 ♂ 27-xi. San José del Cabo, 1 ♀ 25-x.

Pachylia syces Hübner, 1822.

The sole specimen taken is typical. The species occurs almost everywhere in the American tropics.

Baja California Sur: Bahia de Palmas, 1 ♀ 12-xi.

Hemeroplanes parce parce Fabricius, 1775.

This pretty little species is found throughout the tropics. Typical specimens were taken by the mainland party in Mazatlan, but the excellent series from the peninsula proves to be a distinct subspecies apparently endemic to Baja California Sur.

Sinaloa: Flamingo Motel, Mazatlan, 1 ♂ 29-x, at lights. 18 miles north of Mazatlan, 8 ♂ 1 ♀ 2-xi, at ultra-violet light (1 ♂ in Cary collection).

Hemeroplanes parce guaycura subsp. nov. (Fig. 8, 9.)

Slightly smaller than *H. p. parce* (Fig. 10, 11) the fore wing measures 55 to 60 mm. compared to 65 mm. average for typical specimens. The ground color of *guaycura* is a very light tan irrorated with darker brown and some white. Some of the 118 specimens in the type series are a little darker than average but in no case is there any trace of the rich, dark reddish brown so characteristic of *p. parce*.

The body differs little from that of *p. parce*, both having the lappets a darker brown and both having three darker triangles on the dorsal side of the abdomen.

Apex of the fore wing slightly more extended in *guaycura*. The curving white line terminating in the apex is less prominent because it lies in a much lighter ground color. The light dot at the base of the wing above is silvery in *parce* but flat white in *guaycura*. The silver discal spot and the watered lines near the costal margin are identically shaped in both subspecies.

The hind wing is more sharply indented at the anal angle in *guaycura*, but is marked and colored the same in both forms except that the bluish white lines in the dark spot near the anal angle tend to be stronger and cleaner in *guaycura*.

Beneath the markings are similar in the two subspecies, but whereas the ground color in *parce* is blackish brown blending into orange red at the bases of the wings, in *guaycura* the ground is light tan and the undulating rows of black dots crossing the wings are much less prominent, and not so deep black in color.

Male genitalia: Very similar to *p. parce*, as would be expected of subspecies, with only minor differences. Gnathos one-fifth the length of the tegumen plus uncus, but in *parce* it is one-fourth.

Seventy ♂, 53 ♀ all taken at ultra-violet light.

Holotype ♂, Hotel Guaycura, La Paz, Baja California Sur, 10-xi (genitalia slide 961).

Paratypes, all Baja California Sur: Hotel Guaycura, La Paz, 5 ♂ 2 ♀ 20-x (2 ♂ in Cary collection), 6 ♂ 5 ♀ 21-x, 2 ♂ 3 ♀ 22-x, 2 ♂ 2 ♀ 23-x (1 ♀ in Cary collection), 6 ♂ 4 ♀ 26-x (1 ♂ in Cary collection), 5 ♂ 2 ♀ 27-x, 4 ♂ 1 ♀ 28-x



Fig. 8. *Hemeroplanes parce guaycura* subsp. nov., holotype ♂, La Paz, Baja California. Upper side



Fig. 9. *Hemeroplanes parce guaycura*. Same as Fig. 8. Under side



Fig. 10. *Hemeroplanes parce parce* (Fabricius), male, near Concordia, Sinaloa, Mexico, in Carnegie Museum. Upper side

(2♂ in Cary collection), 1♂ 1♀ 29-x (♂ in Cary collection), 3♂ 4♀ 21-x, 3♂ 2♀ 3-xi, 1♂ 3♀ 5-xi, 3♀ 6-xi, 7♂ 3♀ 7-xi, 2♂ 8-xi (1♂ in Cary collection), 2♂ 1♀ 9-xi, 1♂ 10-xi, 3♂ 2♀ 29-xi, 3♀ 3-xii, 2♂ 3♀ 4-xii (1♂ in Cary collection), 3♂ 2♀ 5-xii, 3♀ 6-xii. Bahia de Palmas, 1♂ 1♀ 24-x, 1♂ 12-xi, 1♂ 17-xi, 1♀ 20-xi, 2♂ 27-xi. Rancho Palmarito, 1♂ 30-xi (genitalia slide 960), 1♂ 1♀ 3-xii. San José del Cabo, 1♂ 26-xi. La Purisima, 3♂ 3-xii (genitalia slide 962). Total: 70♂, 53♀.



Fig. 11. *Hemeroplanes parce parce* (Fabricius). Same as Fig. 10. Under side

The lovely hotel in La Paz where the expedition made its principal headquarters, the site of a great deal of the light-trap work, is named after an extinct Indian tribe, the Guaycura, who once lived on the peninsula, and I follow in naming this attractive moth.

Cautethia spuria Boisduval, 1875.

This tropical species is known only from mainland Mexico; it was not taken on the peninsula.

Sinaloa: Sixteen miles north of Mazatlan, 2 ♀ 28-x, at ultra-violet light.

Pholus vitis Linne, 1758.

A typical neotropical species, it was not unexpected to find it on Baja California.

Baja California: Hotel Guaycura, La Paz, 1 ♂ 18-x. Rancho Palmarito, 1 ♀ 30-x. Arroyo San Bartolo, 1 ♀ 1-xi, 1 ♀ 15-xi (in Cary collection). Bahía de Palmas, 1 ♀ 24-x, 2 ♀ 27-xi. Rancho Agua Blanco, 1 ♀ 14-xi. San José del Cabo, 1 ♂ 25-x. Puerto Chilena, 2 ♂ 26-xi (1 in Cary collection).

Pholus fasciatus Sulzer, 1776.

It is surprising that only a single female of this common species, distributed from Canada to Patagonia, was taken. Probably it flies on the peninsula earlier in the season.

Baja California: San José del Cabo, 1 ♀ 25-x.

Xlyophanes tersa Linne, 1771.

A "universal" species, found from Canada to Argentina with no geographic variation. It occurs also on the peninsula.

Baja California: Hotel Guaycura, La Paz, 1 ♀ 1-xii. Arroyo San Bartolo, 1 ♀ 1-xi, 1 ♀ 13-xi. Bahía de Palmas, 1 ♀ 24-x. Puerto Chilena, 1 ♀ 22-xi.

Celerio lineata Fabricius, 1775.

This is found almost everywhere in both the New and the Old World.

Baja California: Hotel Guaycura, La Paz, 1 ♀ 20-x, 3 ♂ 2 ♀ 21-x, 1 ♀ 22-x, 2 ♀ 23-x, 1 ♂ 26-x, 1 ♀ 28-x. Rancho Palmarito, 1 ♀ 3-xii. Bahía de Palmas, 1 ♂ 3 ♀ 24-x, 1 ♂ 17-xi, 1 ♂ 27-xi. San José del Cabo, 3 ♀ 25-x, 1 ♀ 23-xi. Puerto Chilena, 2 ♀ 24-xi.



Fig. 12. Dissected valve of holotype ♂, *Phlegethontius rusticus cortesi* subsp. nov.

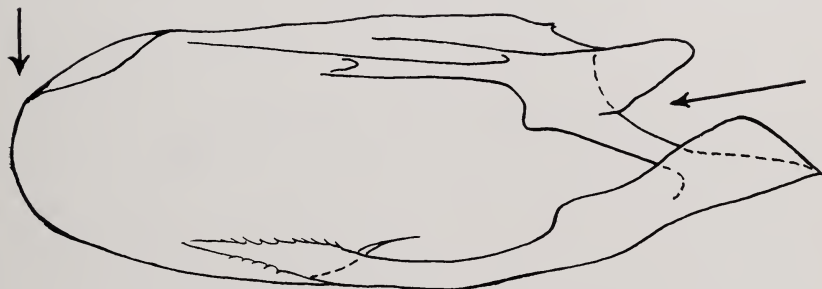


Fig. 13. Dissected valve of male *Phlegontius rusticus rusticus*

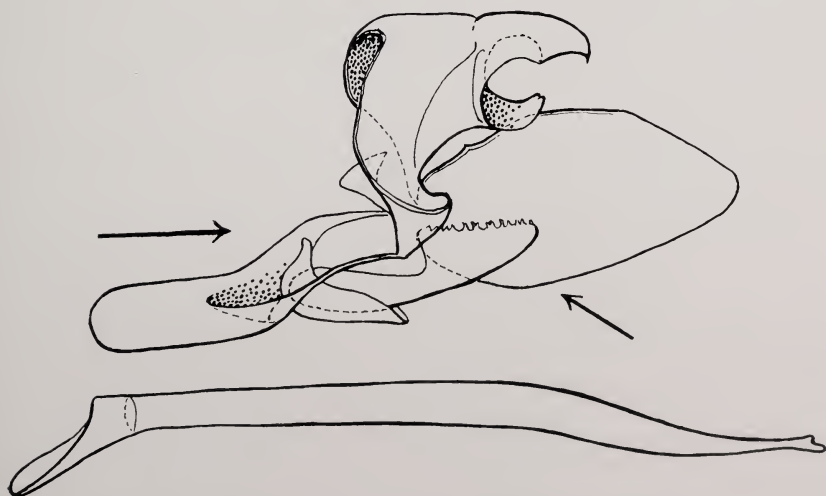


Fig. 14. Genitalia of holotype ♂, *Sphinx xantus* sp. nov.

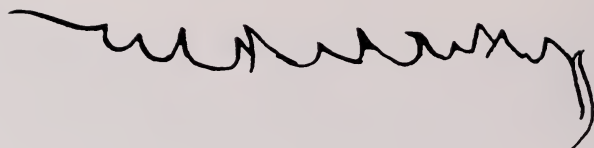


Fig. 15. Dentition at margin of harpogne, holotype ♂, *Sphinx xantus*, enlarged

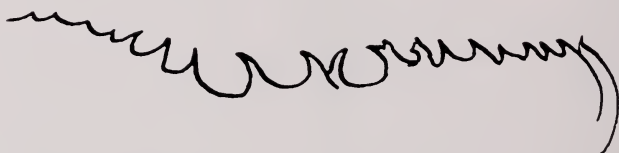


Fig. 16. Dentition at margin of harpogne, paratype ♂, *Sphinx xantus*, enlarged

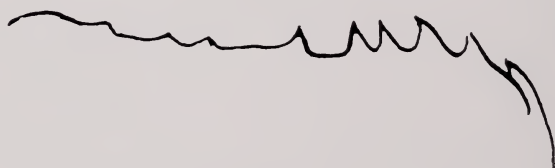


Fig. 17. Dentition at margin of harpogne, a male *Sphinx istar*, enlarged

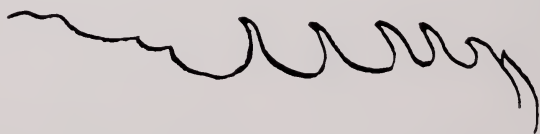


Fig. 18. Dentition at margin of harpogne, another male *Sphinx istar*, enlarged

ART. 18. REPORTS ON THE MARGARET M. CARY AND
CARNEGIE MUSEUM EXPEDITION TO
BAJA CALIFORNIA, MEXICO, 1961

3. A Portable Ultra-violet Insect Trap

BY JEAN W. FOX
Section of Insects and Spiders

[This is the third of a series of papers based on the Margaret M. Cary and Carnegie Museum Expedition to Baja California, Mexico. For an account of the itinerary and description of the localities, see the first paper in this series, by Richard M. Fox. In *Annals of Carnegie Museum*, v. 36, page 181 to 192.]

For the expedition it was important to have the most efficient light trap possible, since a major objective was collecting Sphingidae. From personal experience as well as advice from experienced collectors, Mrs. Cary was particularly interested in the use of black light. There are definite requirements for a trap suitable for such a field trip as was planned. It must be portable, yet packed to withstand rough travel; both lighting and current sources must be interchangeable; it must be literally self-supporting, since in much of the desert area no trees would be available from which to suspend it.

Numerous papers discuss a variety of light traps, but none met our specifications. Frost (1952) summarized many such publications and gave an extensive bibliography, but his emphasis was on those used for pest control, few of which are suitable for traveling field parties. Most of the older traps employed a lantern or incandescent light. Williams (1939), who made a detailed report on moths captured over a period of four years, used a 200-watt gas-filled, clear electric bulb. Robinson and Robinson (1950) studied illuminations effective for moth attraction using a medium power mercury vapor lamp. Holtzman (1961) wrote a specific report on collecting Sphingidae, also using a mercury vapor light source. In discussing collecting at Rancho Grande, Beebe (1949) mentioned their "portable UV machines" but presented no details. Fleming (1947), who was with Beebe, described a variety of collecting equipment with no reference to ultra-violet light in his first or subsequent papers. Peterson's (1934, 1937) exhaustive manual on equipment does not include ultra-violet equipment.

In 1957, Mr. A. C. Lloyd of the Carnegie Museum staff, designed and constructed of cardboard and wire the prototype of a portable light trap, to be used with an electric light. After field testing at Powdermill Nature Reserve, the Museum's research station in Westmoreland County, Pa., a number of permanent models were made of sheet metal and used extensively for moth collecting at the Reserve and elsewhere.

Prior to the Baja California expedition, Mr. Lloyd altered his basic model to utilize black light and made other changes to facilitate portability and flexibility of operation. Construction details of the evolved model are illustrated in Figures 1 to 3, and the assembled trap is shown in Figure 4. It was constructed of galvanized iron with a wooden tripod and fitted to take a standard five gallon food jar as a killing bottle. The entire trap was suspended, when in use, from a heavy eye at the apex of the tripod, and the

vanes are so arranged that a circline ultra-violet tube, an incandescent bulb or a lantern could be used as light source. It could be completely disassembled for flat packing.

The hinged roof was made with an inch overlap at its apex for protection against rain. The two sets of vanes could be folded flat around the center hook. Four trapezoidal funnel sections were hinged together with a loose pin hinge on the fourth side. After a large hole was cut out of a five-gallon jar lid, the rim was welded to a piece which was attached to the bottom of the funnel by means of loose-pin hinges.

The tripod was constructed of $\frac{7}{8}$ -inch doweling with the legs made in two sections, each three feet long, which could be fitted together by metal collars.

A carrying case, 41 by $16\frac{1}{2}$ by $7\frac{1}{4}$ inches, was built with $\frac{7}{8}$ -inch plywood sides and top and $\frac{1}{2}$ -inch poplar bottom and ends. All edges were metal stripped with reinforced corners. The lid was made deep enough so the tripod legs could be secured in it by means of turn bolts. The bottom was subdivided with fiber board partitions to accommodate the rest of the equipment.

The whole ensemble is compact and rugged but too heavy to be lugged for any distance. In the field it was transported by car or pack animal.

Electrical equipment is arranged so the trap can be operated either from house current or a car battery. In the latter case it is desirable to carry an extra battery to facilitate recharging without interference with field work. This was made possible by mounting in the expedition vehicle two batteries connected to a heavy duty generator; a dash-board switch controlled the charging of either one. An inverter is needed to correct the battery current from direct to alternating current. Fig. 3 shows the mounting used for the ultra-violet light and associated equipment. This fixture slides over the cross-bar of the vanes and is equipped with a waterproof male socket to which a waterproof extension cord can be plugged. The circline lamp specified produces, in addition to visible light, ultra-violet black light in the 3600 angstrom range. It requires 110-volt alternating current and is rated at 22 watts. The specific items used were:

Ballast:	General Electric 89-G-499
Starter:	Hubbel FS-2
Starter base:	Hubbel 2947
Circline connection:	General Electric ALF 582-06
Circline lamp:	Westinghouse FC-8-T-9-BL
Inverter:	Cornell-Dubilier 6/12VD6
Safety goggles:	American Optical, Cruxite A, F9946, 6-1/2 CC, 6CVE

It is hardly possible to present irrefutable evidence of the collecting advantages of black light over white since to do so would necessitate the use of two different traps in the same place at the same time. Experiments with living material do not lend themselves to the absolute statistical precision which can be achieved in the physical sciences. Nevertheless, there is much evidence both from the laboratory and the field that ultra-violet light has a stronger attraction for insects. According to Dethier (1953) insects respond to radiations from about 2537 to 7000 angstroms, compared to man's range of approximately 4000 to 7800 (Ford, 1955), and therefore are greatly at-

tracted to black light. Schneirla (1953) states that Lutz (1924) and Bertholf (1932) proved that many insects are attracted to plants by a sensitivity to the ultra-violet emanation from the leaves, not perceived by man. Wigglesworth (1947) in a well documented chapter on insect vision concludes that light-seeking insects show a preference for the ultra-violet range.

Mrs. Cary told the author of an experience she had when collecting in Jamaica. After a number of previous trips there, ultra-violet light was used for the first time in 1957. She said she was utterly astonished at the clouds of insects which appeared compared to the catch of former years.

Since the collecting in Baja California was almost entirely in virgin territory, there is no basis for comparison to offer, but large catches were taken.

The equipment was operated in the field for more than 300 hours, both from battery and from house current and, for a few hours, using a gasoline pressure lantern.

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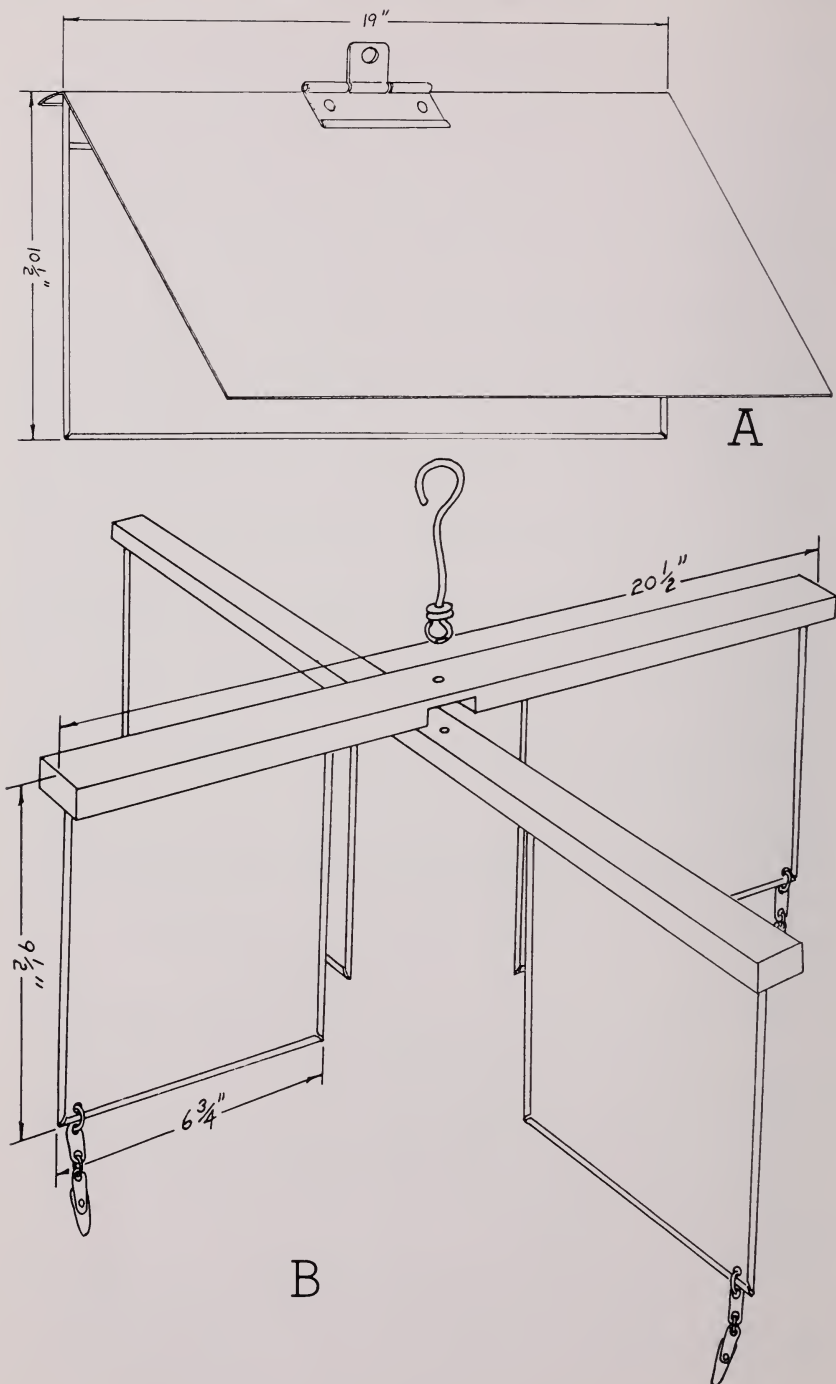
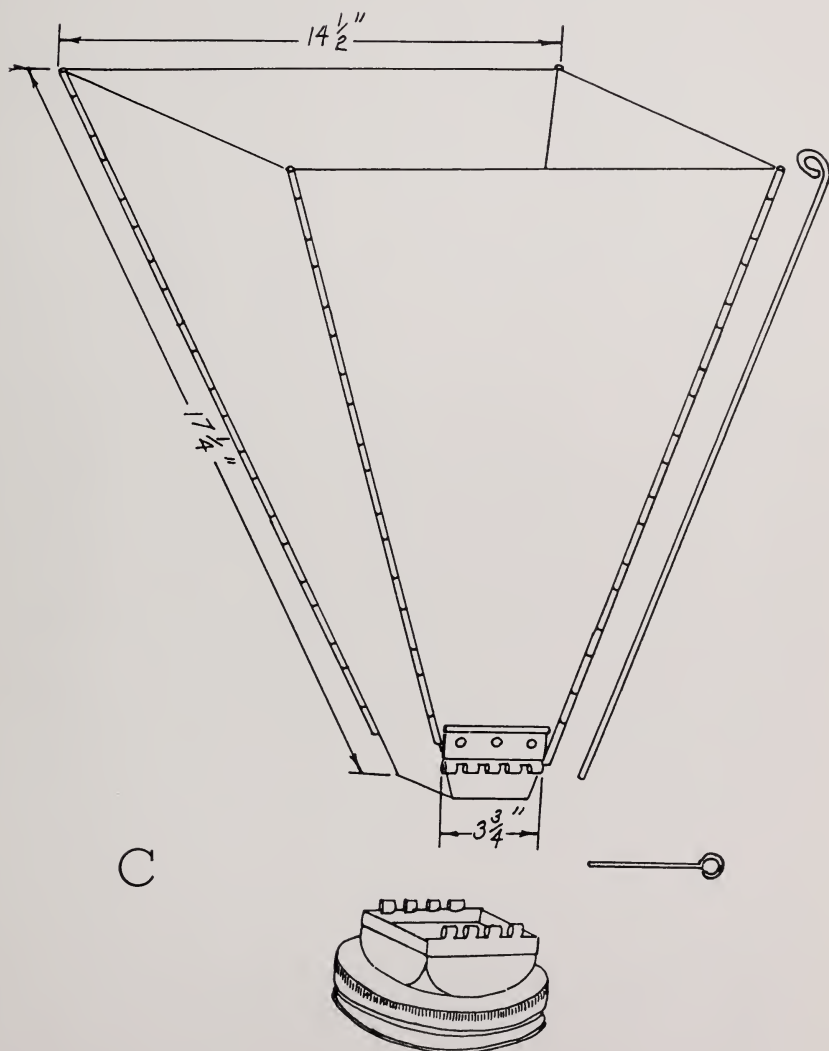


Fig. 1. Details of light trap construction. A. Roof. B. Vanes. C. Funnel



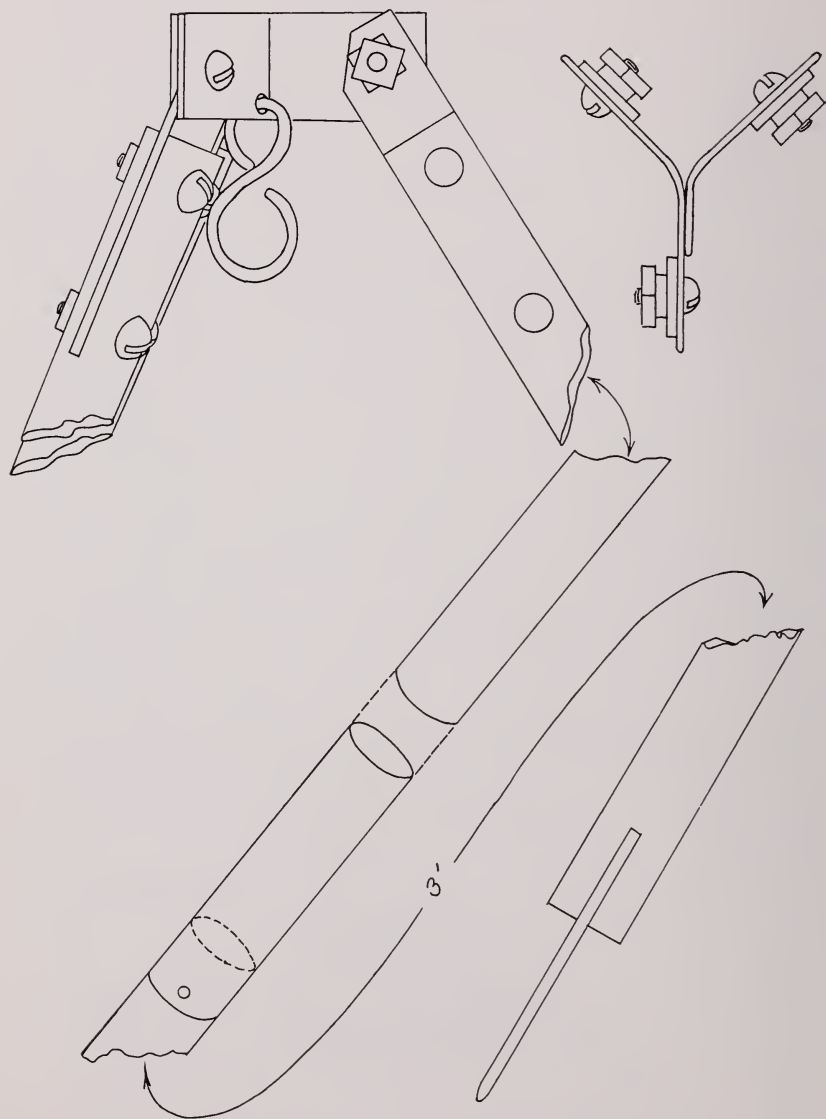


Fig. 2. Details of tripod construction

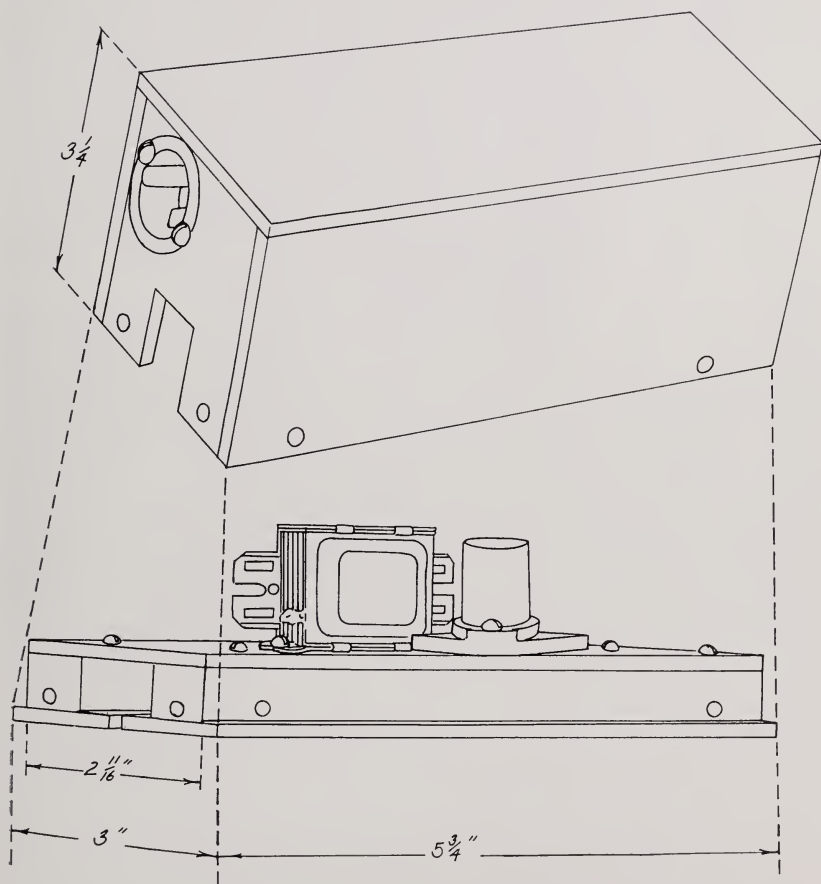


Fig. 3. Electrical equipment assembly
(All drawings by R. T. Satterwhite)



Fig. 4. Expedition members adjusting light trap at operational site in Baja California, Mexico. (Photograph by R. M. Fox)

ART. 19. NEW AFRICAN BUTTERFLIES

By RICHARD M. FOX

Associate Curator, Section of Insects and Spiders

In connection with a study of the butterflies of Liberia, West Africa*, it has been found necessary to rearrange completely the extensive collections of African butterflies in Carnegie Museum. This paper is to record previously unnamed species and subspecies in the families Pieridae, Danaide, Satyridae and Nymphalidae observed in the course of this work. All types and paratypes are in Carnegie Museum except as otherwise noted.

Because the rain forest in Africa is discontinuous, especially along the West Coast, some of the widely distributed species characteristic of it tend to form subspecies with, for example, one in the Sierra Leone, Liberia and Ivory Coast forest, and another in the forests of coastal Cameroons. Differences between such subspecies are always constant, but they may not necessarily be particularly striking, and as a rule are much less striking than differences between seasonal generations. Some species exhibit a range of variation within a population which is greater, though affecting other characters, than subspecific differences. It is generally essential, in evaluating subspecies for the first time, to be able to compare directly good series of the species from many localities and representing all seasons. It is only by such procedure that one can avoid the error, so often committed in the past, of giving formal names to seasonal generations or to aberrations.

FAMILY PIERIDAE

Nepheronia argia hollandi subsp. nov.

Nepheronia argia is distributed throughout tropical Africa. *N. a. argia* was described by Fabricius (1775, p. 470) from Sierra Leone and the subspecies is characteristic of the West African forest as far east as Nigeria. East of the Rift in Kenya and thence to South Africa *N. a. varia* is found. A third subspecies inhabits Central Africa from Cameroons to Gabun, eastward to Uganda. While the males of each of these subspecies are constant in coloring, the females everywhere are variable and, unfortunately, nearly every possible combination has been named in the past. The ground color of the female may be either white like the males or it may be yellow, and the coloring on the fore and hind wings may be different; on the base of the fore wing an orange or pink spot may be present or absent.

But while infrasubspecific variation has received a singular amount of attention in the form of unnecessary names, subspecific distribution has been neglected. Van Son (1949, p. 91) in discussing this species quoted Trimen (1889, p. 181) as having recorded males of both *argia* and *varia* from Zululand "flying side by side," and decided not to recognize subspecies in *argia*. Trimen actually wrote, "One Zululand male has the border very nearly as well developed as in West African specimens."

The very large collections in Carnegie Museum demonstrate beyond doubt that this species exists in at least three subspecies, differing from each other particularly in the width and development of the black markings in both

* Under National Science Foundation Grant G-14048. This is the fifth paper from this grant.

sexes, regardless of the coloring of the female. In males it is convenient to evaluate the width of the marginal black by measuring along M_1 of the fore wing. In *N. a. argia* the length of M_1 passing through white coloring is equal to or shorter than the length passing through the black border, whereas in *varia* and *hollandi* this vein passes through a greater length of white than black coloring. *N. a. varia* is distinguished from the other two subspecies by the fact that the black marginal marking is curtailed toward the anal angle of the fore wing and almost never reaches farther posterior than Cu_1 , frequently breaks into separate spots behind M_2 and lacks acute teeth pointing inward over the veins. In *argia* and *hollandi* the black margins of the fore wings reach at least down to Cu_2 and acute black teeth are present at the veins. Males and white females of *argia* have a distinctly bluish tone on the white ground color, while the subspecies of Central and of East Africa have the white coloring only slightly bluish at most, while generally it is chalky, flat white or slightly creamy; this feature is, of course, obscured in yellow and orange females.

The width of the black margins in females can be evaluated, as in the males, by a measurement along M_1 of the fore wing, or along M_1 of the hind wing. Twelve females from West Africa in Carnegie Museum represent three color variants, but all have the black margin of the hind wing at least 8 mm. wide at M_1 . The females of *hollandi* all have this same black spot no more than 7 mm. wide and generally only 5 or 6 mm. Females of *varia* are readily recognized by the presence of pale spots in the black margino-apical band, giving it a lacy appearance.

Type material, 144 males, 26 females from Cameroons, Congo, Fernando Po, Gabun and Uganda.

Holotype ♂: Efulen, Cameroons; H. L. Weber; November 27, 1912, Carnegie Museum Accession 4794.

Paratypes: Cameroons: Efulen, 41 ♂, 6 ♀; Lolodorf, 29 ♂, 4 ♀; Metet, 27 ♂; Elat, 6 ♂, 1 ♀; Edea, 1 ♂; Mesomba, 1 ♂; Nyabizimbi, 1 ♂; 'Njabilobi, 1 ♂; Mengola, 1 ♂; Bafia, 1 ♂, 1 ♀; Sangmelima, 4 ♂; Akok, 1 ♂; Ajap, 1 ♂; 'Nkom, 1 ♀; Efufap, 1 ♀; Bule country, 2 ♂, 1 ♀. Fernando Po: 1 ♀. Gabun: Kangwé, Ogawe River, 3 ♂, 1 ♀; Lake Onaga, 1 ♂. Congo: Pembe, [Sanga River], 3 ♂; Medje, 4 ♂. Uganda: Mulange, 11 ♂, 4 ♀.

The type series represents all months of the year. White females bear dates of March and November; white females with orange spots on the fore wings are dated January, February, March, May, June, July, August and November. A female with yellow fore wing and white hind wing is dated December. Yellow, unspotted females are dated May. Yellow females with orange spots were taken in January. There appears to be no seasonal variation in males and no seasonal correlation of the female variation.

Nepheronia thalassina verulana Ward

Ward (1871, p. 59) described *Nepheronia verulana* from Cameroons specimens and figured both sexes (1873 plate 4). Aurivillius (1898, p. 447) placed the name as a synonym for *N. thalassina* (Boisduval) in so far as it applies to males but used it as a non-synonym for the female color variation with orange-yellow fore wings figured by Ward.

N. thalassina exists in two subspecies: one is found in West Africa from Sierra Leone to the Niger River, the other in Central Africa from Cameroons

south to the Congo basin and east into Kenya and Nyassaland. The type locality for Boisduval's *thalassina* is Sierra Leone and that name applies to the West African subspecies. For the Cameroons, Congo, and East Africa subspecies, the oldest available name is *verulana* Ward.

These two subspecies differ with respect to the width of the black marginal coloring of the fore wing, which is wider in *t. thalassina*, narrower in *t. verulana*. The difference in width of the band may be evaluated by a measurement taken from the apex of the fore wing cell along vein M_1 . In *t. thalassina* the distance traversed by M_1 through white is equal to the distance it passes through the black band; in *t. verulana* the breadth of the white part of M_1 is much greater than the breadth of the black part.

In general, *N. t. thalassina* tends to have larger black dots on the hind wings at the outer ends of the veins than does *N. t. verulana*, but this feature is by no means reliable, as West African specimens may have very small dots in a few individuals, while Central African specimens sometimes have large dots. Thus Van Son (1949) was correct in believing that subspecies of *thalassina* can not be distinguished on the basis of these dots.

Specimens from the East African highlands have the black band even narrower than in *verulana* and the hind wing immaculate above, as figured by Van Son (1949), but series at hand for study are not long enough to be certain that the differences are consistent throughout the year.

FAMILY SATYRIDAE

Bicyclus sweadneri sp. nov.

Fig. 1, 2

Six males and a female from the Cameroons and Congo are separated in Carnegie Museum over a label reading, "variant of *M. iccius* or new species," written in the hand of the late Dr. Walter R. Sweadner. While quite similar to *B. iccius* (Hewitson) (1865, p. 96) these specimens differ in male genitalia and in certain pattern elements and represent a separate species apparently not heretofore described. Two additional males from the Congo were located in the American Museum of Natural History collection.

In wing shape *sweadneri* differs from *iccus* in lacking a produced angle at the end of Cu_2 of the hind wing, so that the outer margin curves evenly to the tip of the anal vein. Both sexes are similar to *iccus* in coloring and venation. In the male of both *iccus* and *sweadneri* Rs of the hind wing branches close to the base of M_1 ; the hind wing has two hair pencils, the usual generic pencil in the base of the cell below the radius, and a second one in the lower outer corner of the cell over a mealy patch placed at the branching of M_3 and Cu_1 . The upper side (Fig. 1) is dark brown, the female a little bit lighter than the males, with a postdiscal violet band on the fore wing swinging in a gentle curve from the costal margin down to the anal angle. The hind wing is marked only by a faint admarginal line of lighter brown.

The under side (Fig. 1) has, as in *iccus*, a series of dark brown lines on a paler brown ground and the usual series of ocelli, variable in size and in number from specimen to specimen. Distal of the ocellular series three lines are present. The marginal line is preceded by the rather faint and sinuate submarginal line, and a dark, nearly straight post-median line. Proximal of the ocelli are two heavily brown, nearly straight lines which cross both wings: the median, placed beyond the end of the cell, and the discal, which crosses



Fig. 1. Upper side (left), under side (right) *Bicyclus sweadneri* sp. nov. Holotype ♂, Efulen, Cameroons

the outer third of the cell. In addition, the fore wing has three lighter lines in the basal half of the cell, these being placed perpendicular to the radial vein rather than parallel to the longer outer lines.

On the fore wing *iccius* has the median line almost exactly paralleling the outer margin and the post-median line placed slightly askew so that the space between them and containing the ocelli is half again as wide at the anal vein as at the costal end. In *sweadneri* both these lines are askew with respect to the margin, the median line sloping outward, the post-median sloping inward, so that the space containing the ocelli is far narrower at its anterior end, being at least three times as wide at the anal vein as at the costal end. All specimens of *iccius* in Carnegie Museum agree with Hewitson's figure in having on the fore wing only two ocelli: in Cu_1-Cu_2 and in M_1-M_2 . In *sweadneri* there are four ocelli on the fore wing, one in each cell between M_1 and Cu_2 , although they never are strong and sometimes are vestigial; they are placed in a perfectly straight line.

On the hind wing the post-median line in *sweadneri* is more strongly and evenly curved than in *iccius*, so that the space containing the ocelli is narrower at each end and much wider at the median branches in the former species. In both species ocelli are present in all cells between R_s and A , with two below Cu_2 , though some of them may be vestigial. In *sweadneri* the two ocelli between M_1 and M_3 are located 3-4 mm. away from the post-median line. In

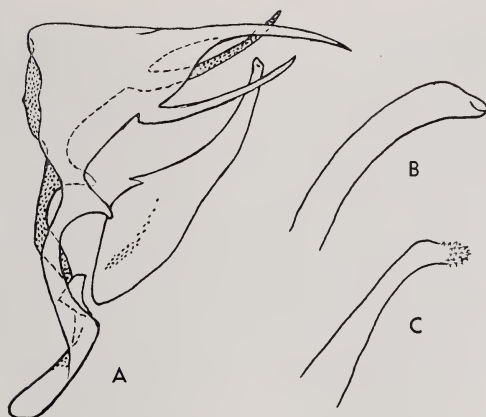


Fig. 2. A. Male genitalia, *Bicyclus sweadneri* subsp. nov. Holotype B. Tip of valve greatly magnified, *B. sweadneri* subsp. nov. Holotype C. Tip of valve greatly magnified, *B. iccius* (Hewitson)

iccius these two ocelli are displaced distad and lie only 1-2 mm. from the post-median line.

Male genitalia (Fig. 2, A) with fully fused tegumen and uncus, the latter long and slender and about the same length and general shape as the gnathoi; saccus short; valve with apical half narrow and produced, terminal armature microscopic. The tip of the valve seen under sufficient magnification (Fig. 2, B) is found to be a narrow, more or less cylindric process without denticulations at the terminus; Fig. 2, B is rotated 90° compared with the orientation shown in Fig. 2, A. The tip of the valve of *B. iccius* (Fig. 2, C) is armed with a cluster of tiny denticulations.

Holotype ♂: Efulen, Cameroons; H. L. Weber, January 26, 1926; Carnegie Museum accession number 8190; genitalia slide 858.

Paratypes: 1 ♀, Efulen, Cameroons; H. L. Weber, September 17, 1912. 1 ♂, Metet, Cameroons; A. I. Good, September 19, 1918. 1 ♂, Elat, Cameroons; A. I. Good, January 2, 1923; Holland Collection. 1 ♂, Elat, Cameroons; A. I. Good, deposited in collection Institut Française d'Afrique Noire, Dakar, Senegal. 1 ♂, Bafia, Cameroons; A. I. Good, January 28, 1928. 1 ♂, Medje, Congo; Lang and Chapin, August 13, 1910, from American Museum of Natural History. (determined *B. iccius* Hewitson, by Holland, 1920). 2 ♂, Medje Congo; Lang and Chapin, August 5 and 11-24 respectively, 1910; collection American Museum of Natural History.

Bicyclus evadne subignobilis Strand

Fig. 3-4

Cramer (1782, v. 3, p. 48) described *B. evadne* from Sierra Leone. A large series I collected in Liberia agrees with his figure in every respect. In Carnegie Museum 82 males and 10 females from the rain forests of Cameroons, Spanish Guinea and Gabun represent a distinct subspecies not heretofore recognized. The pattern on the under sides of the wings of both sexes is, in the Cameroons population, much more strongly contrasting, with all dark



Fig. 3. Upper side (left), under side (right) *Bicyclus evadne subignobilis* Strand, ♂, Batanga, Cameroons



Fig. 4. Upper side (left), under side (right) *B. e. subignobilis* Strand, ♀, Batanga, Cameroons

markings darker and all light markings lighter than in *B. e. evadne*. The ocellus in cell $Rs-M_1$ of the hind wing is slightly smaller in Sierra Leone and Liberia specimens, with the orange ring surrounding it confined to the space between the veins, while in Cameroons specimens the larger ocellus is ringed by orange which crosses M_1 . Furthermore the ocellus in M_2-M_3 is displaced toward the margin of the wing in Cameroons specimens, so that it forms a curve with the ocelli immediately above and below it, rather than a straight line as in *B. e. evadne*. On the upper sides, males of both subspecies are alike,

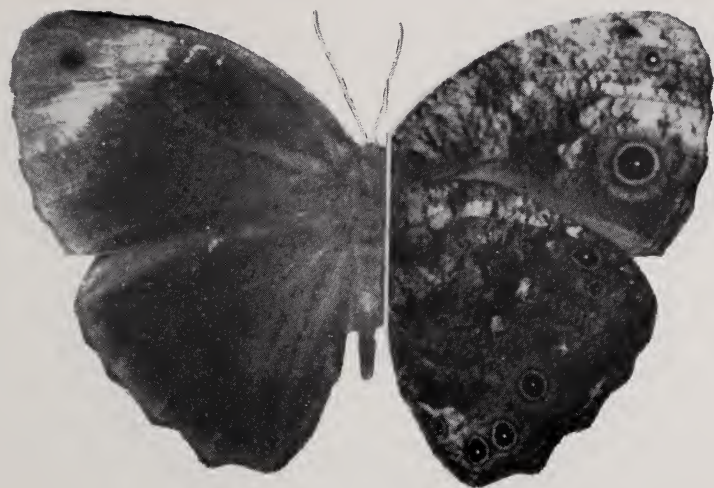


Fig. 5. Upper side (left), under side (right) *Bicyclus auricruda fulgida* subsp. nov. Holotype ♂, Lolodorf, Cameroons

but the Cameroons females have the lighter band crossing the fore wing colored a dusky ocher cream; Sierra Leone females have this band poorly marked, of a deep brown but little paler than the ground color.

Strand (1913) mentioned (p. 144) two males of *evadne* taken by the Tessmann Expedition at Alen, Spanish Guinea. A few pages later (p. 159) he described as new *Mycalesis subignobilis*, principally by comparison with *M. ignobilis* Butler. The true affinities of this species can not be deduced from Strand's description, which was based on two females from Alen, Spanish Guinea. Monsieur Condamin, entomologist with the Institut Français d'Afrique Noire, advises me that he has examined the holotype of *M. subignobilis* and finds that it is the Cameroons subspecies of *B. evadne* for which the Strand name must therefore be used.

Bicyclus auricruda fulgida subsp. nov.

Fig. 5-6

Sixty-six males and thirty females in Carnegie Museum from Cameroons, Spanish Guinea and Gabon are subspecifically different from the sixteen males and two females I collected in the Liberian forests. The latter match exactly Butler's figures (1869, plate 3, Fig. 6) of *B. a. auricruda* described from what then was the Gold Coast.

Male. The transverse creamy patch (Fig. 5) crossing the apex of the fore wing is better developed than in *a. auricruda*, being wider and continuous from the costal margin to the outer margin above Cu_1 . The ground color in the apex beyond this patch is paler than the ground color of the disk, so that the black ocellus in M_1-M_2 stands out strongly. In *a. auricruda* the creamy band is represented by only a small area from M_3-Cu_1 , which is cut off sharply in M_2-M_3 , and by some separated light scaling near the costs. The ground

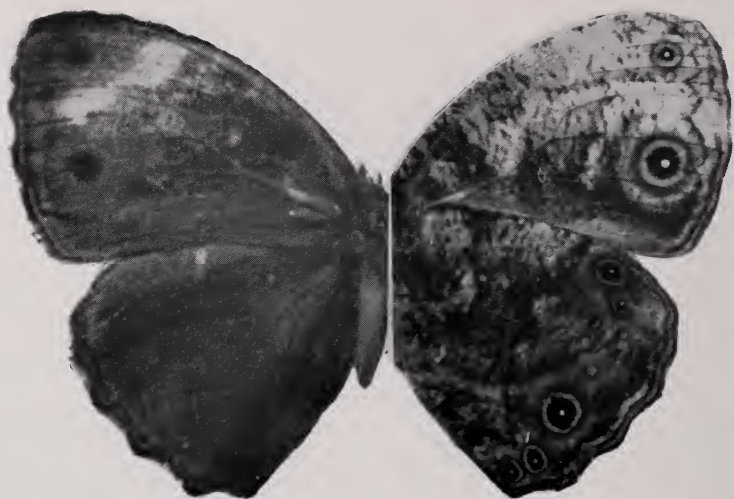


Fig. 6. Upper side (left), underside (right) *B. a. fulgida* subsp. nov. Paratype ♀, Lolodorf, Cameroons

color in the apex is as dark as that of the discal area so that the ocellus does not stand out.

On the under side (Fig. 5) the creamy coloring in the apex of the fore wing is much more extensive than in *a. auricruda*, predominating in the areas above M_2 and extending so that the costal margin above the end of the cell is as light as the creamy spot in M_3-Cu_1 ; in *auricruda* the purple brown coloring fills the apex above M_2 , surrounds the ocellus and in general forms a square, while the costal margin above the end of the cell is darker than the pale coloring between Cu_1 and M_3 . On the other hand, the hind wing of *fulgida* gives the appearance of being darker, as the deep brownish purple between the discal and median lines, especially at the cubical branches, is quite strong and is darker than the ground color surrounding the ocelli; in *auricruda* only the median is as dark, while the ground color on each side of it is of a similar but much lighter color.

Female. Like the male, the ground color on the upper side (Fig. 6) is just a little more ocher brown and is lighter than in *auricruda*, as a consequence of which the ocelli of the fore wing seem to be more prominent, not submerged into the ground color. The transverse creamy band is similar in both subspecies. On the hind wing *fulgida* has a pale creamy admarginal line which is much more prominent than the gray colored line of *auricruda*.

On the under side (Fig. 6) the apex and the costal area above the end of the cell of *fulgida* are much lighter than in *auricruda* and the cubital part of the hind wing is darker, though not so prominently so as in the male.

Holotype ♂: Lolodorf, Cameroons; A. I. Good, November 4, 1914; Carnegie Museum accession number 5737.

Paratypes: Cameroons: Lolodorf, 10 ♂, 9 ♀, January, March, May, October-November, December; Efulen, 16 ♂, 3 ♀, February, April, July, September, October, November, December; Batanga, 8 ♂, 1 ♀, February, April, May,



Fig. 7. Upper side (left), under side (right) *Bicyclus miriam jefferyi* subsp. nov. Holotype ♂, Kitale, Kenya

June, November; Elat, 1 ♂; Campo, 1 ♂, August; Metet, 5 ♀, July, August; no specific locality, 3 ♂. Spanish Guinea: Bonita, 1 ♂, November. Gabun: Kwangwé, Ogawe River, 8 ♂, 7 ♀; Talaguga, 2 ♂; no specific locality, 1 ♀. Congo: Medje, 1 ♂, 1 ♀. No data, 13 ♂, 4 ♀ from the Holland Collection (probably Cameroons). A pair from Lolodorf, Cameroons, and a pair from Kangwé, Gabun, have been deposited in collection Institut Française d'Afrique Noire.

Bicyclus miriam jefferyi subsp. nov.

Fig. 7

Fabricius (1793, p. 214) cited "India" as the habitat of *miriam*, but the name has always been used for Central and West African specimens. It is more likely that the type came from the West Coast than from East Africa. A series at hand from Kitale, Kenya, collected by W. Jeffery, are subspecifically distinct from the excellent series of the Cameroons and the West Coast in Carnegie Museum.

Male and Female. On the upper side (Fig. 7) neither sex differs from *m. miriam*. On the under side (Fig. 7) the ocelli are smaller and poorly developed. In particular the ocellus in Cu_1 - Cu_2 of the fore wing, which is so prominent in *m. miriam*, is markedly reduced in *m. jefferyi*, with the darker concentric rings almost the same value as the ground color, giving this and other ocelli the appearance of being tiny, since only the black centers stand out. Furthermore, the light brown areas of the ground are darker than in *m. miriam*, and the dark lines crossing the wings are lighter. The general effect is that the under side is almost unmarked and that the ocelli are reduced to dots.

Holotype ♂: Kitale, Kenya, British East Africa; Jeffery; Carnegie Museum accession 8156; Nov. 5, 1926. Genitalia slide 385J.

Paratypes: 9 ♂, 5 ♀, Kitale, Kenya; Jeffery. 8 ♂, 4 ♀ in Carnegie Museum, 1 ♂, 1 ♀ deposited in collection Institut Française d'Afrique Noire, Dakar, Senegal.



Fig. 8. Upper side *Charaxes violetta melloni* subsp. nov. Holotype ♂, Nguru Mountains, Tanganyika

It is noted that Strand (1909, p. 105) recorded "punctifera" from Kenya, but since it was described as an aberration the name has no status.

Undoubtedly *jefferyi* is found in much dryer situations than is *miriam* of the rain forest. A long series of *miriam* in Carnegie Museum represents both dry and wet seasons and there is almost no difference in pattern. The pattern reduction found in *jefferyi* is not approached by any specimens seen from West or Central Africa. Further, the type series of *jefferyi* were collected as follows: 1 ♂, 1 ♀ in February; 1 ♂ in March; 3 ♀ in June; 1 ♂ in October and 3 ♂, 2 ♀ in November. No significant variation in pattern development is noted.

FAMILY NYMPHALIDAE

Charaxes violetta melloni subsp. nov.

Fig. 8-9

Van Someren and Rogers record (1928, p. 12) that typical *violetta* "is found over a limited area in the coastal forests [of Kenya] and in the Teita country." Van Someren adds (1935, p. 185) that it is also found in the Meru forest, where "males do not seem to differ, but the dark areas of the fore wings of the females are darker, more blue-black than in coastal examples."



Fig. 9. Upper side *C. v. melloni* subsp. nov. Paratype ♀, 'Nguru Mountains, Tanganyika

A male in Carnegie Museum collected by T. H. E. Jackson at Amani, Tanganyika, is typical *violetta*, and the material from coastal Kenya agrees in all respects with Van Someren's descriptions and illustrations.

The Matthew T. Mellon East Africa Expedition took three males and a female in the 'Nguru Mountains of Tanganyika at an elevation of 3000 feet, which represent a distinct subspecies. The Meru forest examples reported by Van Someren apparently tend a little toward this new subspecies but are part of the coastal subspecies.

Males and females of *C. v. melloni* differ from those of *v. violetta* in having all black areas above on both wings, much blacker and with stronger blue and violet reflections. Both sexes have on the under sides the dark parts of the pattern appreciably darker, especially in the triangle on the fore wing beyond the median band and in the interspace between the submedian and median lines.

The male (Fig. 8) has, in addition, a light blue-purple spot on the upper side of the hind wing between Sc and M, and a similarly colored spot in M_1-M_2 ; the discal band of the hind wing continues, therefore, anterior to Sc. In *v. violetta* the discal band ends with the streak just above M_2 and is represented in Sc- M_1 only by two small separated dots. On the fore wing the discal band is a little wider in *v. melloni* than in *v. violetta*, and this is particularly evident with respect to the element in Cu_2-A . On the hind wing the

light discal band is narrower below M_2 in such a way that the black area beyond it is definitely wider in *melloni* than in *violetta*.

The most prominent difference in females (Fig. 9) is the white discal band of the hind wing, which in *melloni* is only two millimeters wide at M_2 , about half the width of the same band in *violetta*.

Holotype ♂, one ♀ and 2 ♂ paratypes from the 'Nguru Mountains, north-eastern Tanganyika, 3000 ft.; September 18, 1960, in baited trap, collected by the Matthew T. Mellon East Africa Expedition.

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HARVARD
UNIVERSITYART. 20. FOSSIL AMPHIBIANS AND REPTILES OF
FRANKSTOWN CAVE, PENNSYLVANIA

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In 1926 Peterson reported on the Pleistocene fossils recovered from Frankstown Cave, located in Blair County, Pennsylvania (for a description of this cave and bone deposit see Holland, 1908, and Peterson, 1926). In studying Pleistocene reptile remains that are currently being recovered from a sinkhole near New Paris, Bedford County, Pennsylvania, (see Guilday and Bender, 1958), it was necessary to restudy the amphibian and reptile material from Frankstown Cave. The two sites are approximately 30 miles apart in the same valley.

Peterson recognized six families and six genera of amphibians and reptiles. A re-examination of the material discloses that two of these families are not present. The bones that Peterson referred to *Cryptobranchus* and *Eumeces* were misidentified; neither genus is represented in this material. It is now possible to recognize at least seven genera of snakes, including the one listed by Peterson. With the present additions and corrections, the list of amphibians and reptiles of Frankstown Cave includes seven families and 13 genera. The nature of the material does not permit specific identification; the one exception is a portion of the plastron of a wood turtle that is distinctive.

These specimens are all in the collections of the Section of Vertebrate Fossils of Carnegie Museum.

CLASS: AMPHIBIA

Order: CAUDATA

Family: Plethodontidae

Genus ?

Cryptobranchus, Peterson 1926, p. 251 (Fig. 1.)

Material: 11149, a proximal caudal vertebra.

Remarks: The single caudal vertebra is that of a plethodont salamander approximately the size of *Plethodon glutinosus*. It is not *Cryptobranchus*.

Family: Salamandridae

Diemictylus cf. *viridescens*—Red-spotted Newt*Plethodon cinereus*, Peterson 1926, p. 251

Material: 11150, 8 vertebrae; 11151, 2 vertebrae.

Remarks: These vertebrae are opisthocoelus, with a high neural crest, and are in all respects similar to those of *D. viridescens* living in the area today.

Order: SALIENTIA

Family: Bufonidae

Bufo cf. *americanus*—American Toad*Rana catesbeiana*, Peterson 1926, p. 252

Material: 11133, ilia and limb bones; 11143, three very small ilia.

Remarks: No. 11133 includes the ilia and limb bones of what appears to be one individual. In size they are larger than the similar bones in most recent *B. americanus*, but they still fall within the expected size range.

Family: Ranidae

Rana sp.—Frog

Material: 11138, 1 sacral vertebra; 11139, 8th and 9th vertebrae; 11141, 2 sacral vertebrae; 11147, 1 ilium, an 8th vertebra, and 1 sacral vertebra.

Remarks: The bones that Peterson referred to *Rana* are the ones here referred to *Bufo*. No. 11139 is of interest in having centra of these two vertebrae solidly fused, while the zygapophyses are not fused. The sacral vertebrae are very close in appearance to those of *Rana pipiens*.

CLASS: REPTILIA

Order: TESTUDINATA

Family: Testudinidae

Clemmys insculpta, Peterson 1926, pp. 253-254—Wood TurtleMaterial: 11065 is the right hyoplastron of a mature *C. insculpta*. Catalogued under the same number is a fragment of a neural that in size and thickness could also be of this species.

Order: SQUAMATA

Suborder: Sauria

Eumeces anthracinus, Peterson 1926, pp. 252-253 (Fig. 2.)

Remarks: Peterson referred two vertebrae, 11311 and one "fragment of a bony plate" to this genus and species. The two vertebrae are small mid-body vertebrae of a salientian, while the "bony plate," 11313 is a fragment of a fossil bryozoan that had weathered out of the limestone walls of the cave. No lizard remains have been found in this collection nor have they been found in the extensive collections from the Pleistocene deposit in the New Paris sinkhole, although both *Sceloporus* and *Eumeces* occur in this valley today.

Suborder: Serpentes

Family: Colubridae

Material: *Storeria* sp.—Brown Snake, 11051, 19 vertebrae.

Thamnophis cf. *sirtalis*—Common Garter Snake, 11321, 15 vertebrae; 11322, 1 right maxilla.

Thamnophis sirtalis, Peterson 1926, p. 253

Thamnophis sp. Gilmore, 1938, p. 69

Heterodon, sp., Hognose Snake, 11177, 1 broken vertebra.

Diadophis sp., Ringneck Snake, 11178, 1 vertebra.

Carphophis sp., Worm Snake, 11351, 1 vertebra.

Lampropeltis cf. *doliata*, Milk Snake, 11513, 9 vertebrae of a very young individual.

Family: Crotalidae

Crotalus sp., Rattlesnake, 11514, 1 vertebra of a small individual.

Remarks: No attempt was made to assign specific names to these specimens. The vertebrae referred to *Thamnophis* compare in all details with mature *T. sirtalis*. In the lot, as examined by Gilmore (1938), there were "about 34" vertebrae; of these, I have separated 15 that resemble *sirtalis* and another group of 37 (11176) that, while *Natrix*-inae, could be either *Natrix* or *Thamnophis*. Today these two genera are represented in western Pennsylvania by three species each. Examination of recent skeletal material of these shows a wide range of both individual and ontogenetic variation.

Of interest in this collection is the presence of *Carphophis*, a snake of southern affinities, that today reaches the northern limits of its range in Pennsylvania. This small snake is such an active burrower that its presence in this material does not necessarily indicate that it occurred there during the Pleistocene. More likely it entered the fissure and became trapped in some more recent period.

All of the genera recovered occur today in the general area around Frankstown. Reptiles and amphibians are relatively small, and there is the possibility that some, or all of these, could have worked their way into this fissure at a later period than that when the large Pleistocene mammals became trapped. It is noteworthy that, with the exception of *Carphophis*, all of the genera reported here have ranges today that extend into Canada.

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ART. 21. SCOLECODONTS OF THE DELAWARE LIMESTONE, DEVONIAN OF OHIO AND ONTARIO

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Discrete scolecodonts are plentiful in the Delaware limestone of Devonian age and all localities examined produced scores of specimens. This study does not by any means include all the forms that probably occur. Since the matrix is limestone and subject to some agitation at the time of deposition, complete assemblages of jaws were not found. Also the jaws are secured from the limestone by treatment with acid, which tends to separate them. Occasionally a maxilla I or II was found with a smaller jaw adhering to it in possible articulation.

During the past few years a number of paleontologists, Kielan-Jaworowska (1961), Kozłowski (1956), Lang (1949), have erected new genera for articulated scolecodonts or assemblages in complete disregard for the International Rules on Zoological Nomenclature. Due to certain problems and disagreements conodont specialists are apparently having difficulties in working out a classification and nomenclature for their disjunct specimens and assemblages. A dual nomenclature has been the result. It may be that scolecodont workers have followed unwittingly along this rather dubious path of unsettled issues and for this reason have erected unnecessarily an illegal dual nomenclature. The jaw apparatus of modern and fossil polychaete is relatively simple. A scolecodont jaw assemblage usually contains a jaw of a well established fossil genus based on an existing genus. Thus there seems to be little reason for new genera for known forms and a dual nomenclature in scolecodont classification. In this paper the genus *Paulinites*, Lang, 1947, is placed under the genus *Nereidavus*, Grinnell, 1877, and the genera *Vistulella* and *Mochtyella*, Kielan-Jaworowska, 1961, are included under the genus *Staurocephalites*, Hinde, 1879.

Kielan-Jaworowska has taken exception in a paper (1961) to the use of the word "fossa" for the muscle cavity of an annelid tooth and has introduced the term "pulp cavity." This term is used in the description of the vertebrate tooth, which is in no way homologous to the annelid tooth. The use of the word "pulp" implies that it is the same material found in the cavity of the vertebrate tooth. Anatomically the word "fossa" (Latin: ditch or trench) is in common use. Webster's Unabridged Dictionary defines fossa (anat.) as a pit, groove, cavity or depression of greater or less depth. The Century Dictionary defines fossa as any depression, pit or hollow in a structure, specified by a qualifying term. Zoologically, a fossa is described as a depression or a deep pit in the hard integument of an animal, often opening into a cavity and serving for the point of attachment of an organ. More than 40 examples are given for the use of the word. It may be that the term "pulp cavity" was adapted from conodont terminology which is also of a questionable nature.

Genus ARABELLITES Hinde, 1879

Arabellites goniocercus sp. nov.

Maxilla I. Plate 1, Fig. 1

The jaw is elongate, suboblong in outline, and angular posteriorly. The figured specimen measures 0.72 mm. in length. Along the straight inner margin, which is about one-third the length of the jaw, a series of seven or eight small, sharp-pointed, backward-directed denticles extends to the posterior end. The denticles are nearly uniform in size. About two-thirds of the jaw consists of a wide, hooked fang that narrows abruptly to a sharp point. The posterior end is wide and truncate. Along the outer margin a narrow shank-like projection is slightly hooked at the anterior end and forms a small, rounded notch. A wide, shallow fossa occupies about one-third of the posterior area of the jaw. The margins of the fossa are rounded and slightly thickened.

There is a general similarity between this form and a number of other species. *Arabellites contractus* Hinde (1882), *Arabellites rectidens* Eller (1940) and *Arabellites hamiltonensis* (Stauffer) (1941) are similar except for the size of the fossa and fang and the presence of the shank on the outer margin. Locality: Goderich, Ontario.

Arabellites comis Eller

Maxilla I. Plate 1, Fig. 2, 3, 4

Arabellites comis Eller, 1938. Annals of the Carnegie Museum, v. 27, p. 277, pl. 28, fig. 9.

Arabellites comis Stauffer, 1939. Journal of paleontology, v. 13, no. 5, p. 501-502, pl. 58, fig. 21, 22, 28.

Arabellites comis Sylvester, 1959. Journal of paleontology, v. 33, no. 1, p. 40, pl. 5, fig. 1-4.

Several specimens bear on the obliquely truncate posterior end a small pointed projection. This seems to occur on specimens whose denticles are larger and not so pointed. The figured specimens measure about 0.67 mm. in length. Locality: St. Mary's, Ontario; Goderich, Ontario.

Genus NEREIDAVUS Grinnell, 1877

Nereidavus forcicarinatus sp. nov.

Maxilla I. Plate 1, Fig. 5, 6

The jaw is narrow and elongate and the figured specimen measures 0.67 mm. in length and 0.2 mm. at the widest part. Along the slightly curved inner margin a series of very minute, nearly equal-sized denticles extends for a short distance at the central part of the jaw. A large, hooked, sharp-pointed fang is directed backward. Both the denticles and the fang are nearly oblique to the underside of the jaw. The posterior third of the jaw is occupied by a deep rectangularly-shaped fossa. The margins of the fossa are thickened and rounded and the inner margin is extended to form a straight-sided flange that is slightly oblique. The flange is also slightly concave. A convex area is present in the lower half of the fossa. The surface of the jaw adjacent to the

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denticles is concave. When observed from the side opposite the fossa, a heavy ridge or keel that is forked is discernible at the posterior end near the outer margin. This structure is not reflected on the other side. The posterior end of the jaw is truncate except for a small notch.

Nereidavus forcicarinatus is a typical form of the genus *Nereidavus*. It is similar to a number of species but differs in details. Usually the denticles of *Nereidavus* species extend from the fang nearly to the posterior extremity. *Nereidavus forcicarinatus* seems to have only a few denticles located at the mid-area of the inner margin. The fossa and the area opposite on the under side of the jaw are not comparable with other forms. Locality: Delaware, Ohio.

Nereidavus incrassatus sp. nov.

Maxilla I. Plate 1, Fig. 7, 8, 11, 12, 13

Measurements of the narrow, elongate figured specimens range from 0.92 mm. to 1.92 mm. in length. Along the nearly straight inner margin a series of 20 to 25 small, mostly rounded denticles extends nearly the full length of the jaw. Very minute denticles are actually present on or at the base of the fang. They increase gradually in size posteriorly. A large, thickened fang is curved backward and is slightly oblique to the surface of the jaw. The outer margin is slightly irregular in outline but in general it is parallel to the inner margin. The posterior margin is indented by a large, angular bight. A rather narrow, shallow fossa occupies about one-fourth the length of the jaw. The margins of the fossa are thickened and rounded, especially the anterior margin, which forms a ridge and extends to the outer margin as a small flange or spur. Adjacent to the fossa the inner margin is extended to form a flattened to slightly concave flange. The surface of the jaw is generally convex while the opposite surface is usually irregularly concave.

Nereidavus incrassatus resembles *Nereidavus harbisonae* Eller (1941) and *Nereidavus paranaensis* (Lange) (1947). They differ in the width of the jaw, the character and arrangement of the denticles, the shape of the fossa and the presence of a flange on the inner margin. More closely related to *Nereidavus incrassatus* is *Nereidavus ontarioensis* Stauffer (1939). The size of the fang, the shape of the fossa, and details of the posterior end are dissimilar. Locality: Delaware, Ohio; St. Mary's, Ontario.

Nereidavus hastatus sp. nov.

Maxilla I. Plate 1, Fig. 9, 10

The jaw is small and elongate and the figured specimen measures 0.52 mm. in length. There is only a suggestion of denticles on the inner margin near the posterior end. It is possible that the jaw is completely void of teeth. The spear-shaped fang points in a forward direction. An irregularly shaped fossa occupies about one-fourth of the jaw. The margins of the fossa are thickened and rounded. A straight-sided flange slightly oblique to the surface is present on the inner margin adjacent to the fossa. The surface of the jaw is irregular while the opposite surface is convex except for a depressed area at the posterior end. The truncate posterior margin is very slightly indented and oblique.

On some specimens of *Nereidavus invisibilis* Eller (1940) the denticles seem to be missing or are only stubs. In other scolecodont forms it has been noticed

that the teeth decrease in size and may gradually disappear and form a sharp ridge. At first it was questioned whether this form should be placed in the genus *Nereidavus* because of the apparent lack of denticles. The elongate form, the fossa, and the posterior end are, however, typical for the genus *Nereidavus*. There is a possibility that *Eunicites angulatus* Eller (1938) (1955) belongs to the genus *Nereidavus* since the general shape is similar and the fossa and posterior region resemble these structures in *Nereidavus hastatus*. Locality: St. Mary's, Ontario.

Nereidavus incomptus sp. nov.

Maxilla I. Plate 1, Fig. 14, 15

This narrow and elongate jaw is represented by a number of well preserved specimens, all about the same size. The figured jaw measures 0.82 mm. in length. Along the inner margin a series of very minute denticles is present. In the figures of the jaw the denticles are shown actually larger than they are since it was impossible to draw them any smaller. Some specimens seemed to be unadorned with any teeth at all while others had mere suggestions. Usually the denticles are located at the central part of the jaw. A long, thin fang is hooked backward and is slightly oblique to the side of the jaw. A large, deep fossa occupies about one-fourth of the jaw. The margins of the fossa are thickened and rounded. The anterior margin of the fossa is extended to the outer margin to form a small protuberance. A long, fairly wide flange is present adjacent to the fossa on the inner margin. The surface of the jaw is irregular with a deep concave area at the posterior end. The opposite surface is convex. The posterior end is truncate or slightly indented.

Nereidavus incomptus is similar to *Nereidavus harbisonae* Eller (1941). There is a difference in the size of the denticles and the fossa and the presence of a protuberance on the outer margin. It is possible that *Nereidavus incomptus* is the right paired jaw of *Nereidavus incrassatus*, Plate 1, Fig. 7, 8, 11, 12, 13. Locality: Delaware, Ohio.

Nereidavus harbisonae Eller

Maxilla II

Nereidavus harbisonae Eller, 1941. Annals of the Carnegie Museum, v. 28, p. 325, 326, pl. 37, fig. 1, 2, 4, 5.

Nereidavus harbisonae Sylvester, 1959. Journal of paleontology, v. 33, p. 47, pl. 6, fig. 21, 22, 23, 24.

This form is fairly common and was found at a number of localities of the Delaware Limestone.

DRILONEREISITES gen. nov.

Jaws of this genus are characterized by a large fang or primary denticle as long or longer than the jaw proper. Along the inner margin, often on an elevated ridge, a series of small to medium-sized denticles, usually nearly uniform in size, extend to or nearly to the posterior extremity. A round to elongate fossa is present. Adjacent to the denticles and forming the inner

margin of the fossa is a narrow to wide shank which is sub-rectangular in shape. Its margin is straight or slightly rounded. The posterior end of the jaw is truncate and the margin is usually incurved.

Genotype, *Drilonereisites longicusculus* sp. nov.

Jaws of this kind were originally included under the genus *Arabellites*. Hinde (1879) in erecting the genus *Arabellites* stated the following: "I propose to include in this genus jaws of widely different form, which have a general resemblance to the existing genus *Arabellites* Grube. Jaws with an extremely prominent anterior hook, and a row of smaller teeth on a wide base." A number of closely related species described by Hinde, Stauffer, and Eller under the genera *Arabellites* and *Protarabellites* are so unlike any forms found under these genera that a new genus seems advisable. *Drilonereisites* is based on the existing genus *Drilonereis* Claparède which has an extremely long fang or hook and a rather small base. Stauffer (1933) erected a genus *Protarabellites* and described forms that will be included under *Drilonereisites*. Stauffer's genotype, *Protarabellites humilis* is a completely different type of jaw than those to be placed under *Drilonereisites*. *Arabellites spicatus* var. *contractus* Hinde (1880), *Arabellites contractus* Hinde (1882), *Protarabellites excelsus* Stauffer (1939), *Protarabellites hamiltonensis* Stauffer (1939), *Arabellites hamiltonensis* (Stauffer) (1941), *Arabellites rectidens* Eller (1940), *Arabellites rectidens* ? Eller (1945), *Arabellites arrectus* Eller (1955), and *Drilonereisites longicusculus*, pl. 3, fig. 1, 2, 3, and *Drilonereisites gracillimus*, pl. 1, fig. 16, 17, described in this paper will be included under the genus *Drilonereisites*.

Drilonereisites longicusculus sp. nov.

Maxilla I. Plate 3, Fig. 1, 2, 3, 4

The jaw is narrowly elongate and the figured specimens measure from 0.75 mm. to 0.92 mm. in length. A series of about 14 minute, conical denticles is located on a narrow, elevated ridge which is parallel to the inner margin. The denticles are nearly the same size and extend only partway to the posterior end. About two-thirds of the jaw consists of a rather long, heavy, sharp-pointed, hooked fang. From the fang the outer margin is incurved slightly to the posterior. A small round fossa is present on one side. The anterior and inner margins of the fossa are in the form of a rounded ridge while the outer margin is extended into a wide shank. The underside of the jaw is irregularly convex and concave while the upperside does not reflect exactly the underside but is mostly convex. The posterior end of the jaw is slightly obliquely truncate with an irregularly-curved margin.

Hinde (1882) described two species, *Arabellites spicatus* var. *contractus* and *Arabellites contractus* Hinde (1882) which resemble *Drilonereisites longicusculus* except for the size and length of the fang and the character of the denticles and fossa. The fang of *Protarabellites excelsus* Stauffer (1939) resembles that of *Drilonereisites longicusculus* but differs in the size of the denticles and the width of the jaw. *Protarabellites hamiltonensis* Stauffer (1939) and *Arabellites hamiltonensis* (Stauffer) (1941) do not have as long a fang but are similar to *Drilonereisites longicusculus* in the arrangement of the denticles and the shape of the shank. There is a similarity between *Drilonereisites*

longicusculus and *Arabellites rectidens* ? Eller (1945) and *Arabellites arrectus* Eller (1955) in the size and character of the fang and the general shape of the jaw. They differ in the size of the teeth and the fossa. Locality: Delaware, Ohio; Benmiller, Ontario.

Drilonereisites gracillimus sp. nov.

Maxilla I. Plate 1, Fig. 16, 17

This jaw is elongate and very slender. The figured specimen measures 0.67 mm. in length and 0.19 mm. in width. Only six very small, sharp-pointed, backward-directed denticles are present on the inner margin. They are located at the posterior area of the jaw but do not extend to the end. Most of the jaw consists of a large, hooked, angular fang which is slightly oblique to the underside. Less than one-third of the jaw is taken up by a deep, irregularly shaped fossa. It is oval at the anterior and narrows to a groove at the posterior. The margins of the fossa are thickened and rounded. An irregularly shaped flange is present on the outer margin opposite the fossa. The posterior end is angular and slightly notched.

Drilonereisites gracillimus is similar in a general way to several other species. It closely resembles *Drilonereisites longicusculus*, pl. 3, fig. 1, 2, 3, except that it is not as wide proportionately in the anterior part. Locality: Benmiller, Ontario.

Genus ILDRAITES Eller, 1936

Ildraites incredibilis sp. nov.

Maxilla I. Plate 1, Fig. 18

The jaw is incredibly large and except for the shank is fairly narrow for its length. It is possible that a small portion of the posterior end of the jaw is missing. The figured specimen measures 2.57 mm. in length. Possibly it would measure near three millimeters if complete. Along the inner margin a series of seven large, blunt, conical, backward-directed denticles extends the full length of the jaw. The first denticle is rounded and hardly has the appearance of a tooth in some specimens. The remaining denticles decrease in size gradually to the posterior. A large blunt fang points in a forward direction. On smaller specimens the fang is more sharply pointed. The fang and denticles are only slightly oblique to the surface of the jaw. On the outer margin a wide, deep, crescent-shaped bight forms with the fang a long, narrow, slightly curved shank. If the shank were not broken it is estimated that the figured specimen would be nearly two millimeters wide. Except for the fang a shallow fossa occupies most of the side of the jaw and shank. The margins of the fossa are thickened and rounded. On the shank the margin is flattened and becomes wide toward the end.

Ildraites incredibilis is unlike other species of *Ildraites* due to the arrangement and length of the shank. Usually the shank is fairly short and points in a posterior direction. In most species of *Ildraites* the fang and the denticles are oblique or nearly perpendicular to the under surface of the jaw. In *Ildraites incredibilis* they are only slightly so. Locality: Goderich, Ontario.

Ildraites insignis sp. nov.

Maxilla I. Plate 1, Fig. 19, 20

The jaw is wide and the figured specimen measures 0.70 mm. in length and 0.32 mm. in width. Adjacent to the inner margin a series of six fairly large, conical, sharp-pointed, backward-directed denticles extends to the posterior end. The fang is short, wide, blunt, well-hooked, and oblique to the under side of the jaw. A wide, shallow bight present on the outer margin emphasizes a small but wide shank. The fossa is large, wide, and shallow with a convex area in the center. The margins of the fossa are thickened and rounded especially along the inner margin. A concave area is present adjacent to the denticles. The posterior end of the jaw is narrow and slightly curved. A knob-like mark is present near the outer margin at the posterior end.

There is a general resemblance between *Ildraites insignis* and a number of species described under this genus. *Ildraites camurus* Eller (1940, 1942) and *Ildraites anatinus* (Stauffer) (1939) have characters similar to *Ildraites insignis*. They differ in the number of denticles and the width of the jaw. Hinde (1882) described a species *Arabellites spicatus* Hinde that is like *Ildraites insignis* except for the number of denticles and the shape of the bight. Locality: St. Mary's, Ontario.

Ildraites invalidus sp. nov.

Maxilla I. Plate 1, Fig. 21, 22

The jaw is small and wide, and tapers abruptly to a narrow, slightly curved posterior end. The figured specimen measures 0.52 mm. in length and 0.27 mm. in width. Along the inner margin a series of eight or nine rather large, conical, sharp-pointed, backward-directed denticles extends to the posterior end. From the anterior the denticles gradually become oblique to the under surface of the jaw. Only a short space is present between the denticles and the small, sharp-pointed, slightly hooked fang. The outer margin is nearly straight or slightly incurved to about the mid-area where it forms a short, wide, heavy shank. A small, narrow, not very strong bight emphasizes the width and shortness of the shank. The fossa is narrow and long and occupies about one-half the surface of the jaw. The margins of the fossa are slightly thickened and rounded. The side of the jaw is concave adjacent to the denticles but highly convex at the outer side. These contours are reflected on the opposite surface of the jaw.

There is a similarity between *Ildraites invalidus* and *Ildraites bowenensis* Eller (1941) and especially *Ildraites patulus* Eller (1942). These species all have the small space between the denticles and the fang. *Ildraites invalidus* differs from these forms in the shape and size of the fossa and the character of the bight. Locality: Cheapside, Ontario.

Ildraites unexpectatus sp. nov.

Maxilla I. Plate 1, Fig. 24, 25, 26

The jaw is narrow and the figured specimen measures 0.70 mm. in length and 0.27 mm. in width. Along the slightly curved inner margin a series of eight or nine conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. The first denticle is minute and it is followed by

teeth that are unexpectedly large in comparison to the size of the jaw. They decrease in size gradually to the posterior end. A large, conical, sharp-pointed, fang is well hooked. Beginning at the anterior the denticles gradually become oblique to the side of the jaw and toward the posterior may be perpendicular. The outer margin incurves slightly and then forms a small, angular shank. A small, narrow, rounded bight emphasizes the size and character of the shank and the narrowness of the posterior end. Most of the surface of the jaw is occupied by a shallow fossa. The margins of the fossa are thickened and rounded except in the region of the shank. The surface of the jaw is concave adjacent to the denticles and irregularly convex and concave at the outer half of the jaw. This configuration is reflected in the fossa and shank on the opposite side of the jaw.

Ildraites fritzae Eller (1942) is similar to *Ildraites unexpectatus* except that the latter is not so long, the bight deeper, and it has one small denticle following the fang instead of two. Locality: Delaware, Ohio.

Ildraites anatinus (Stauffer)

Maxilla I

Arabellites anatinus Stauffer, 1939. Journal of paleontology, v. 13, p. 501, pl. 58, fig. 40, 41, 42, 50.

Ildraites anatinus Eller, 1941. Annals of the Carnegie Museum, v. 28, p. 329, 330, pl. 37, fig. 17, 18.

Ildraites anatinus (Stauffer) seems to be common and widespread in middle Devonian rocks. It was found at several localities in the Delaware Limestone.

Genus LUMBRICONEREITES Ehler, 1868

Lumbriconereites jugosus sp. nov.

Maxilla I, II. Plate 2, Fig. 1, 2, 3, 4, 12

Although the right and left jaws of Maxilla I are asymmetrical and not in an articulated position it is probable that they belong to the same species. The left and right jaws are elongate and the figured specimens measure about 1.35 mm. in length. On the left jaw a series of 15 conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. The first three denticles are medium in size. From the fourth denticle, which is large, the teeth decrease in size gradually to the posterior end. The fang is long, thin, sharp-pointed and only slightly hooked. Most of the denticles are in an oblique position to the under surface of the jaw. A fairly large, rounded shank is present on the inner margin. Posterior to the shank the inner margin incurves slightly and then becomes straight to the posterior end. On the outer margin a very small shank-like projection is found opposite the third denticle of the jaw. It forms a small notch or bight anteriorly. From this flange the outer margin is nearly straight to the posterior end. A large deep fossa occupies nearly all the surface of the jaw. The margins of the fossa are slightly thickened and rounded. The denticles of the right jaw are the same in number, but instead of pointing in a backward direction they are nearly perpendicular to the under surface. The outer margin of the right

jaw curves gently to about the anterior third of the jaw where it abruptly forms a fairly wide, straight-sided flange that extends to the posterior end. The flange determines the shape of the small bight at its anterior end. On the irregularly curved inner margin a narrow, rounded flange is present at about the anterior third of the jaw. A long, narrow, deep fossa is present on the surface.

Adhering or yoked to the anterior margin of both left and right jaws of maxilla I are specimens of maxilla II. It is possible that these jaws are about in natural position or articulation. The posterior extremity of each jaw fits in the notch or bight at the anterior end of the flange on maxilla I. The left jaw of maxilla II is subtriangular in shape and measures about 0.55 mm. in length. A series of 13 or 14 conical, sharp-pointed, backward-directed denticles extends the full length of the well arched jaw. The first five denticles are large and the remaining ones become small rather abruptly. The inner margin is irregularly curved to a small flange where it incurves gently to the posterior end. This incurved margin or bight fits the curvature of the outer, anterior margin of maxilla I. A large, deep fossa occupies most of the one side of the jaw. The margins of the fossa are slightly thickened and rounded. The right jaw, maxilla II, is subtriangular in shape and the figured specimen measures 0.70 mm. in length. A series of 10 conical, sharp-pointed denticles extends nearly to the acute posterior end. The denticles point mostly straight forward and are not oblique to the surface of the jaw. They decrease in size gradually to the posterior. The inner margin is irregularly curved from the anterior end to form a small shank. Posterior to the shank the margin incurves gently in shape to form a shallow bight. The margin of the bight is in articulation with the anterior outer margin of maxilla I. The outer margin incurves gently and forms a wide, rounded shank. The remainder of the outer margin is irregularly curved to the acute posterior extremity. A large, deep fossa occupies nearly all one surface of the jaw. The margins of the fossa are thickened and rounded.

Maxilla I and II of *Lumbriconereites jugosus* were first considered to be *Lumbriconereites cooperi* Eller (1938), maxilla I, and *Paleoenonites alpenaensis* (Eller) (1938), (1955), maxilla II, respectively. There are, on closer examination, a number of differences. The denticles of *Lumbriconereites jugosus* extend to the posterior end while in *Lumbriconereites cooperi* they do not. The flange on the inner margin of *Lumbriconereites jugosus* is more rounded and in a more anterior position. Also the bight is not so pronounced. The left jaw, maxilla I, of *Lumbriconereites jugosus* differs considerably from the left jaw of *Lumbriconereites cooperi* Eller (1938). Again the denticles of *Lumbriconereites jugosus* extend much farther to the posterior than *Lumbriconereites cooperi* Eller. The greatest difference is the presence of a wide flange on the outer margin of the right jaw of *Lumbriconereites jugosus*. This character does not seem to be present on other species of *Lumbriconereites* except for *Lumbriconereites tuberosus* Eller (1945). The left and right jaws of maxilla II are similar to a number of forms described under the genus *Paleoenonites*. They do not correspond very closely to the jaws of maxilla II of *Paleoenonites alpenaensis* (Eller) (1938) (1955). Locality: St. Mary's, Ontario.

Lumbriconereites labiosus sp. nov.

Maxilla I. Plate 2, Fig. 5, 6

Measurements of the length of the figured specimens and duplicates are 0.87 mm. The jaw is wide and most specimens are nearly half as broad as they are long. A series of 12 conical, sharp-pointed, backward-directed denticles extends the full length of the jaw. The denticles are slightly smaller anteriorly than in the center area of the jaw. From the middle they decrease gradually in size to the truncate posterior extremity. The fang is thin and sharp-pointed and is directed in a forward position. The inner margin in-curves from the anterior to form a small bight with a very wide angular shank that extends to the posterior end. The outer margin is broadly curved and does not form a typical shank. A long, very narrow fossa extends the full length of the jaw. The broad large-lipped areas adjacent to the fossa are convex while the opposite side is concave.

Lumbriconereites labiosus reminds one of *Lumbriconereites curvus* Eller (1945) in general characteristics. Neither form resembles other species of *Lumbriconereites* very closely. *Lumbriconereites labiosus* differs from *Lumbriconereites curvus* in the shape and length of the flange on the inner margin and in the length and width of the fossa. There is also a difference in the shape of the outer margin and the direction in which the fang is pointed. Locality: Cheapside, Ontario.

Lumbriconereites flexuosus sp. nov.

Maxilla I. Plate 2, Fig. 7, 8

The jaw is narrow and full of turns and the figured specimen measures 0.60 mm. in length. A series of 10 conical, sharp-pointed, backward-directed denticles extends nearly to the posterior end. The denticles are fairly uniform in size and become smaller only near the posterior. The large conical fang points directly backward while the remaining denticles are slightly oblique to the under surface of the jaw. Adjacent to the fang the inner margin curves inward to form a well defined shank. Posterior to the shank the margin curves in a crescent-shaped bight and then becomes straight to the posterior end. On the outer margin at the anterior end a very prominent shank points in a forward direction. From the shank to the posterior end the margin is nearly straight and parallel with the inner margin. A deep fossa occupies most of one side of the jaw. The margins of the fossa are thickened and rounded.

Lumbriconereites flexuosus is similar to a number of forms. This is especially true of *Lumbriconereites cooperi* Eller (1938), figures 7 and 8. *Lumbriconereites flexuosus* differs from other species in its angularity and the shape and prominence of the shanks. Locality: Cheapside, Ontario.

Lumbriconereites latifrons sp. nov.

Maxilla I. Plate 2, Fig. 9, 10, 13

The jaw is broad-fronted, angular and subrectangular in shape. The figured specimens measure 0.77 mm. in length and 0.32 mm. in width at the anterior end. A series of 10 conical, sharp-pointed denticles extends the full length of the jaw. They are fairly uniform in size except for the posterior tooth, which is minute. The small fang and the following two denticles are

directed slightly forward while the remaining ones point in a backward direction. The obliquity of the denticles including the fang is nearly to the horizontal. The anterior margin is nearly straight, measures 0.40 mm. in width, and forms a small shank with the nearly straight outer margin. The inner margin incurves slightly and then becomes abruptly indented to form a deep crescent-shaped bight. A fossa occupies nearly the complete surface of the jaw. It is wide and shallow anteriorly but becomes narrow and deep at the posterior half. The margins of the fossa are slightly thickened and rounded. The surfaces are irregular in contour.

The angularity and straightness of the margins of *Lumbriconereites latifrons* is not found in other forms of this genus. Locality: Delaware, Ohio.

Lumbriconereites cooperi Eller

Maxilla I

Lumbriconereites cooperi Eller, 1938. Annals of the Carnegie Museum, v. 27, p. 275-277, pl. 28, fig. 5, 6.

Lumbriconereites cooperi Sylvester, 1959. Journal of paleontology, v. 33, p. 45, 46, pl. 6, fig. 9, 10, 11, 12.

Lumbriconereites cooperi ? Eller, 1961. Annals of the Carnegie Museum, v. 36, p. 29, pl. 1, fig. 1, 2, 3.

Lumbriconereites cooperi Eller is probably the most common form of the Delaware Limestone. This is also true of other middle Devonian formations.

Genus LEODICITES Eller, 1940

Leodictes sp. indet.

Maxilla II. Plate 1, Fig. 23

A number of specimens of this sort were found at several localities. Unfortunately all were broken or were not well preserved. The bight and the shank of the figured specimen is probably distorted. Locality, Delaware, Ohio.

Leodictes fluctuosus sp. nov.

Maxilla II. Plate 3, Fig. 11

The jaw is large, wide and subrectangular in shape. The figured specimen measures 1.7 mm. in length and 0.82 mm. in width. Along the curved inner margin a series of 10 blunt, large, triangular denticles extends nearly to the posterior extremity. The first denticle or fang is large and is pointed slightly forward. It is followed by backward-directed denticles that decrease gradually in size posteriorly. From the curved anterior the nearly straight outer margin extends nearly to a point opposite the posterior end of the inner margin to form a blunt shank. A deep, irregularly shaped bight emphasizes the length of the shank. A subtriangularly shaped fossa is present on the surface of the jaw. The outer and posterior margins of the fossa are wide and full of waves or sculptured while the remaining margin is wide and flat. The surfaces of the jaw are irregularly convex and concave.

Leodictes fluctuosus cannot be compared very closely to other forms due to the length of the outer margin and shank. Locality: Goderich, Ontario.

Leodicites inordinatus sp. nov.

Maxilla II. Plate 2, Fig. 14, 15, 16, 21

In outline the jaw is narrowly subtriangular with irregularly curved margins. The figured specimens measure from 0.65 mm. to 0.75 mm. in length. A series of 10 irregular, backward-directed, triangular denticles extends nearly to the posterior end of the jaw. The first denticle is small, hooked and adheres closely to the second larger denticle. In some specimens both the third and fourth denticles may be minute while in other specimens only the third denticle is small. The next denticle is usually fairly large and is perpendicular to the margin of the jaw. The remaining denticles decrease gradually in size to the posterior. Most of the denticles are slightly oblique to the surface of the jaw. An angularly shaped bight is present on the outer margin and it forms, with the anterior margin, a narrow, fairly straight shank. The anterior margin is irregularly rounded and the posterior end is obtuse. The surfaces of the jaw are irregularly convex and concave. A narrow, deep fossa occupies most of one surface of the jaw. The margins of the fossa are slightly thickened and rounded.

There is a general similarity between *Leodicites acclivis* Eller (1942), *Leodicites buris* Eller (1945) and *Leodicites inordinatus*. The species differ in the arrangement of the denticles and the irregularity of the margins. Locality: St. Mary's, Ontario; Goderich, Ontario.

Leodicites inornatus sp. nov.

Maxilla II. Plate 2, Fig. 17

The jaw is small, elongate and narrow. The figured specimen measures 0.35 mm. in length and 0.13 mm. in width. A series of nine conical, sharp-pointed, backward-directed denticles extends nearly to the acute posterior end. The first denticle is large and well hooked. The remaining denticles are large in comparison to the size of the jaw. They decrease gradually in size to the posterior. The outer margin curves gently to a small, narrow shank which in turn forms a small crescent-shaped bight. A narrow maxillary muscle fossa occupies about one-half the posterior end of the jaw. The margins of the fossa are rounded and slightly thickened. The surfaces are smooth and unadorned.

The narrowness of the jaw and the position of the shank make this form different from other species. There is a slight resemblance between *Eunicites cristatus* Hinde (1882) and *Leodicites inornatus*. Locality: St. Mary's, Ontario.

Leodicites finitimus sp. nov.

Maxilla II. Plate 2, Fig. 18, 19

In outline the jaw is narrow and elongate. The figured specimen measures 0.52 mm. in length and about 0.07 mm. in width at the posterior half. A series of 11 sharp-pointed, rectangular, backward-directed denticles extends nearly to the acute posterior extremity. The first two denticles are small and the third is large. The remaining denticles begin with a small one and gradually increase in size to about the mid-area and then decrease in size to the posterior end of the jaw. The denticles are oblique to the surface of the jaw. The rounded anterior margin becomes straight to form a thin, sharp-pointed shank. A crescent-shaped bight is present on the inner margin.

The outer margin curves from the anterior to form a small, sharp-pointed shank and then becomes straight. A deep, narrow fossa extends nearly the full length of the jaw. The margins of the fossa are slightly thickened and rounded.

Leodicites fnitimus borders upon in a general way a number of other forms. It differs in the arrangement of the denticles and the shape and position of the shanks. *Leodicites crassimarginatus* Eller (1961) is similar in outline. Locality: St. Mary's, Ontario.

Leodicites heteropsis sp. nov.

Maxilla II. Plate 2, Fig. 20

The jaw is narrow, elongate and subtriangular in shape. Along the inner margin a series of seven triangular, backward-directed denticles extends to the posterior end of the jaw. The irregularly directed denticles are large for the size of the jaw and decrease in size only slightly to the posterior. The curved anterior margin becomes straight and forms a narrow, sharp-pointed shank. A crescent-shaped bight is present on the outer margin. A deep, narrow fossa begins in the shank and extends to the acute posterior extremity. The margins of the fossa are rounded and thickened. One side of the jaw is convex while the other side is concave, especially near the denticles. The figured specimen measures 0.52 mm. in length.

The narrowness of the jaw and the small number and size of the denticles are features that set *Leodicites heteropsis* apart from other species of *Leodicites*. Locality: St. Mary's, Ontario.

Leodicites incertus sp. nov.

Maxilla II. Plate 3, Fig. 5, 6, 7

In shape the jaw is subtriangular and arched. The figured specimen measures 0.42 mm. in length. Along the curved inner margin a series of 10 medium-to-large, sharp-pointed, triangular denticles extends to the posterior end. The first denticle is small and is followed by two that become slightly larger. The fourth denticle is large, wide and sharp-pointed. The denticles increase slightly in size from the small fifth tooth to the eighth and decrease in size to the posterior. The anterior margin is slightly incurved and forms a narrow, sharp-pointed shank. Midway along the curved outer margin is a small protuberance or shank. A deep, narrow fossa begins at the anterior shank and continues to the posterior end of the jaw. The margins of the fossa are rounded and slightly thickened.

This form is not very similar to any other species. It is, however, typical of the genus and has certain specific details that are found in other forms. *Leodicites biformis* Eller (1945) has the small protuberance similar to *Leodicites incertus*. The irregular size and distribution of the denticles is common in a number of forms of *Leodicites*. Locality: St. Mary's, Ontario.

Leodicites inflatus sp. nov.

Maxilla II. Plate 3, Fig. 13

The jaw is narrow and subtriangular in shape. The figured specimen measures 0.48 mm. in length and 0.28 mm. in width. Along the slightly curved inner margin a series of seven denticles extends nearly to the acute

posterior extremity. The first denticle is medium-sized, conical, sharp-pointed, and slightly hooked. The following tooth is of equal size. The third tooth is blunt, slightly inflated and several times larger than any other denticle. The remaining denticles are small and backward-directed, and decrease in size only slightly to the posterior. The anterior margin is incurved from the fang and forms a small, hooked, sharp-pointed shank which is slightly oblique to the surface of the jaw. Adjacent to this shank and along the curved outer margin is another small, subtriangular shank. A narrow, deep fossa occupies the complete length of the jaw. The margins of the fossa are thickened and rounded.

Leodicites inflatus is similar to *Leodicites incertus*, Plate 3, Fig. 5, 6, 7 but differs in the character and arrangement of the denticles and the shank. Both forms bear the small, secondary shank on the outer margin. Locality: Delaware, Ohio.

Leodicites indecorus sp. nov.

Maxilla II. Plate 3, Fig. 20

The jaw is small and irregularly triangular in shape, and the figured specimen measures 0.37 mm. in length and 0.25 mm. in width. A series of eight blunt, conical denticles extends the full length of the inner margin. The first denticle is large and slightly hooked. The remaining denticles are fairly large for the size of the jaw and are perpendicular to the margin; they decrease in size gradually to the posterior end of the jaw. The anterior margin is rounded, curves abruptly, and forms with the outer margin a large triangular shank. On the surface a large, deep-to-shallow fossa extends nearly the full length of the jaw. In the anterior area of the fossa is a ridge that is not reflected on the opposite side of the jaw. Both the lateral margins of the fossa are wide and flattened toward the posterior end. The area on the surface between the margin of the fossa and the denticles is narrow. The opposite of the jaw is fairly convex and smooth.

Leodicites indecorus is not very similar to other forms of the genus. Locality: Goderich, Ontario.

Leodicites lacunosus sp. nov.

Maxilla II. Plate 4, Fig. 34

In outline the jaw is subtriangular. It is small in size, and the figured specimen measures 0.32 mm. in length and about 0.31 in width. Along the inner side a series of five or six conical, sharp-pointed denticles extends nearly to the acute posterior extremity. The first denticle is slightly larger and thicker than the other teeth and it appears to be a continuation of the margin of the fossa. The remaining denticles are nearly uniform in size or decrease only slightly to the end of the jaw. The anterior margin is angular and forms a small shank with the outer margin. The fossa is a rather deep depression and occupies about two-thirds of the side of the jaw. Two margins of the fossa are thickened and rounded while the third is thin and broken.

This species does not correspond very closely to other forms of the genus. Locality: Goderich, Ontario.

Leodicites lamellosus sp. nov.

Maxilla II. Plate 5, Fig. 18, 19

Since the outer margin is thin and broken, the width of the jaw can only be estimated. In length the jaw measures 0.47 mm. and the width is perhaps 0.35 mm. On the inner margin a series of seven denticles extends nearly to the acute posterior extremity. The first denticle is sharp-pointed and slightly out of alignment with the other teeth. It is followed by a larger, thin tooth that is broken in the figured specimen but was probably pointed. The remaining denticles are triangular and are directed slightly backwards. A small, rounded bight is present on the lower side of the outer margin and it forms a narrow shank with the anterior margin. The side of the jaw adjacent to the narrow shank is concave or flattened; the opposite side is convex. A narrow fossa extends the full length of the jaw. The margin of the under side of the fossa is slightly thickened and rounded. The upper side of the outer margin is extended and thin and broken.

Leodicites lamellosus is similar to *Leodicites brooksi* Eller (1945) except for the width of the upper side of the jaw, the size of the first denticle, and the shape of the under side. Locality: Delaware, Ohio.

Leodicites reimanni Eller

Maxilla II

Leodicites reimanni Eller, 1941, *Annals of the Carnegie Museum*, v. 28, p. 333, 334, pl. 38, fig. 10, 11, 12, 13.

Leodicites reimanni Eller was found only in the Delaware Limestone of Ohio.

Genus PALEOENONITES Eller, 1942

Paleoenonites latidorsatus sp. nov.

Maxilla II. Plate 3, Fig. 8

The jaw is broadly triangular in shape. The figured specimen measures 0.42 mm. in length and 0.37 mm. in width. Along the inner margin a series of seven small, triangular denticles extends nearly to the posterior end of the jaw. The first denticle is long, thin and sharp-pointed and is directed in a forward position. The remaining teeth are triangular in shape, nearly uniform in size, and point only slightly to the posterior. The anterior margin is slightly incurved while the outer margins are broadly curved. A wide, fairly deep, triangular fossa occupies more than one-half the area of the jaw. The margin of the fossa is thickened and rounded while the opposite one is thin and usually broken.

Paleoenonites latidorsatus is similar in a general way to other forms of the genus. It differs in the number and arrangement of the denticles and the shape of the fossa. Locality: Goderich, Ontario.

Paleoenonites informis sp. nov.

Maxilla II. Plate 3, Fig. 9, 19, 26, 27

In outline the jaw is irregularly triangular and the figured specimens measure from 0.40 mm. to 0.65 mm. in length. Along the inner margin a series of seven to nine large, conical, widely-spaced denticles extends nearly

to the posterior end of the jaw. The first denticle is thin, sharp-pointed and slightly hooked. The second denticle may be larger than the first. The remaining teeth decrease in size rapidly to the posterior. The anterior margin incurves to form a sharp-pointed shank that points in a forward direction and is often oblique to the surface of the jaw. This obliquity develops a deep concave groove on the side of the jaw. A deep irregularly shaped fossa occupies the complete length of the jaw. It is wide anteriorly but very narrow in the posterior half of the jaw. The lateral margin is thickened and rounded but the adjacent margin is thin and usually broken.

Most of the specimens of *Paleoenonites informis* were found in a broken condition. The form differs from other species in the number, size and arrangement of the denticles, the shapelessness of the fossa and the curvature of the shank. Locality: Goderich, Ontario.

Paleoenonites incurvus sp. nov.

Maxilla II. Plate 3, Fig. 10

In shape the jaw is wide and subtriangular. The figured specimen measures 0.40 mm. in length and 0.42 mm. in width. On the inner margin a series of seven blunt, triangular denticles extends to the acute posterior end of the jaw. The first denticle or fang is angular and sharp-pointed. It widens rapidly and appears to be part of the anterior margin. The posterior edge of the fang, together with a central ridge, extends to the outer margin. The remaining denticles decrease in size gradually to the posterior. The anterior margin is wide and incurves to form a large and broad shank. Along the anterior area the shank is slightly concave. A large, deep, triangular fossa extends the full length of the jaw. The margin of the side of the fossa is slightly thickened while the opposite one is thin and usually broken.

The general shape of the jaw is similar to many forms of *Paleoenonites*. The character of the first denticle differs considerably from other species. Locality: Cheapside, Ontario.

Paleoenonites latissimus sp. nov.

Maxilla II. Plate 3, Fig. 11

Measurement of the very wide, triangular jaw shows the width to be greater than the length. The figured specimen is 0.45 mm. in length and 0.50 mm. in width. Along the inner margin a series of eight blunt, short, triangular denticles extends nearly to the posterior end of the jaw. The first and second denticles are large and are followed by smaller teeth that decrease in size posteriorly. The anterior margin curves gently and then turns abruptly downward to form a large, wide, triangular, nearly straight-sided shank. A large, fairly deep fossa occupies more than one-half the surface of the jaw. The outer margin of the jaw and the anterior margin of the shank are thickened and rounded. The outer margin of the shank is thin and usually broken. Adjacent to the first denticle the jaw is concave while the posterior and the opposite side are convex.

A number of forms of *Paleoenonites* have a large shank and fossa. *Paleoenonites latissimus* differs from others in its general shape and the character of the denticles. Locality: Benmiller, Ontario.

Paleoenonites hiulcus sp. nov.

Maxilla II. Plate 3, Fig. 12

In outline the jaw is irregularly rectangular and the width is nearly equal to the length. The figured specimen measures 0.52 mm. in length and 0.47 mm. in width. Along the curved inner margin a series of about twelve sharp-pointed, triangular denticles extends nearly to the acute posterior end of the jaw. The first denticle or fang is large and is followed by two more teeth only slightly smaller. The remaining denticles are small and decrease in size posteriorly where they become minute. A large, deep fossa occupies the full length of the jaw. The posterior end of the flange does not connect directly with the end of the jaw, thus leaving a cleft or gap at that end. The margins of the fossa are only slightly thickened and rounded. The area on the surface between the margin of the fossa and the denticles is narrow and slightly concave.

Paleoenonites hiulcus is similar in shape to *Paleoenonites auctificus* Eller (1955). They differ in the number and character of the denticles and the shape of the flange. Locality: St. Mary's, Ontario.

Paleoenonites lacinatus sp. nov.

Maxilla II. Plate 3, Fig. 14, 15

In outline the jaw is irregularly triangular, wide anteriorly, and has the lateral margins tapering to an acutely pointed posterior extremity. Along the inner margin a series of nine or ten blunt-to-medium pointed, triangular denticles extends nearly to the posterior end of the jaw. The first denticle or fang is pointed, and slightly hooked, and its lower edge extends nearly to the outer margin of the jaw. The denticles decrease gradually in size to the posterior. The anterior margin incurves from the first denticle and forms a large, broad shank. A large, deep fossa occupies the full length of the jaw. The anterior and adjacent margins of the fossa are thickened and rounded. The lateral margin is thin and seems to be complete in the figured specimen. Both sides of the jaw have concave areas. The figured specimen measures 0.50 mm. in length and about 0.45 mm. in width.

Paleoenonites lacinatus is very similar to *Paleoenonites alpinaensis* (Eller) (1955) and *Paleoenonites informis*, plate 3, fig. 9, 19, 26, 27. They differ in the number and arrangement of the denticles and the shape of the shank. Locality: St. Mary's, Ontario.

Paleoenonites lacertosus sp. nov.

Maxilla II. Plate 3, Fig. 16, 17

The jaw is angular and subrectangular in shape. The figured specimen measures 0.60 mm. in length. Along the inner margin a series of five strong, large, angular denticles extends about two-thirds the length of the jaw. The first denticle is triangular, medium-pointed, and directed slightly forward, leaving a space between the first two teeth. The remaining denticles are sub-rectangular in shape and are closely arranged without space between them. The outer edge of the denticles is nearly straight. They decrease in size gradually to the posterior. The anterior margin is nearly straight. When the jaw is viewed from the one side a broadly raised ridge is seen to extend to about the mid-area of the outer margin and forms a very small, round

flange. On the opposite side of the jaw the outer margin begins some distance from the anterior and forms a straight-sided obtuse angle. This margin and the inner margin end in an acute posterior extremity. A shallow fossa that extends about two-thirds the length of the jaw is open at the anterior end. The margin of the fossa is slightly thickened.

Paleoenonites lacertosus is not very closely related to other forms of this genus. It is unusual to find the fossa open at the anterior end. The angularity of the jaw and the denticles is not found in many species. The figured specimen does not seem to be broken except slightly at the posterior part of the under side of the jaw. Locality: Goderich, Ontario.

Paleoenonites flaccidus sp. nov.

Maxilla II. Plate 3, Fig. 18

In outline the jaw is irregularly rectangular. The figured specimen measures 0.50 mm. in length and 0.45 mm. in width. Along the curved inner margin a series of about 14 small, sharp-pointed to blunt denticles extends nearly to the posterior end of the jaw. The first two denticles are sharp, narrow and elongate. They are followed by a series of feeble, closely arranged teeth that are nearly uniform in size. The anterior margin is slightly incurved or straight and forms a large, broad shank with the outer margin. The posterior margin of the shank is nearly straight, and perpendicular to the lateral margins. A large, rectangular fossa occupies about two-thirds the side of the jaw. The anterior and inner margins of the fossa are thickened and rounded while the outer margin is thin and usually broken. The area between the margin of the fossa and the denticles is very narrow.

Paleoenonites flaccidus, in a general way, is similar to a number of species of *Paleoenonites*. It differs from other forms in the character and arrangement of the denticles and the shape of the fossa and shank. Locality: St. Mary's, Ontario.

Paleoenonites hexadactylus sp. nov.

Maxilla II. Plate 3, Fig. 21

The jaw is subtriangular in shape and tapers to an acute posterior extremity. The figured specimen measures 0.65 mm. in length. Along the inner margins a series of six sharp-pointed to blunt denticles extends about two-thirds the length of the jaw. The first denticle is thin, sharp-pointed, and directed slightly forward. The remaining denticles are blunt, widely-spaced, and directed slightly backward. They decrease gradually in size to the posterior. The anterior margin is nearly straight. An irregularly shaped shank is present on the outer margin. A large, deep fossa extends the complete length of the jaw. The margins of the fossa are only slightly thickened and rounded. The upper side of the jaw is gently concave while the under side is convex.

Paleoenonites hexadactylus is similar to *Paleoenonites lacertosus*, plate 3, fig. 16, 17, in general shape but differs in the character of the fossa. Locality: Goderich, Ontario.

Paleoenonites latimarginatus sp. nov.

Maxilla II. Plate 3, Fig. 22, 23

In its shape the jaw is irregularly rectangular, and the width is nearly equal to the length. Measurements of the figured specimen are: length 0.45 mm., width 0.37 mm. Along the curved inner margin a series of nine or ten blunt, conical, backward-directed denticles extends the full length of the jaw. The first is fairly large and slightly out of alignment with the others. The remaining denticles decrease in size gradually to a narrow, rounded posterior extremity. From the first denticle the very wide, slightly incurved anterior margin forms a large, broad shank with the rounded outer margin. On one side a deep to shallow fossa occupies most of the jaw. The anterior margin of the fossa is thickened and bears a flattened area adjacent to the fossa and in the incurved area of the margin. The region next to the denticles on the inner side is slightly concave while the outside area is gently convex.

Jaws of this sort seem to be rather scarce. In 1945 Eller described a form *Oenonites* ? *dubius* that is similar to *Paleoenonites latimarginatus*. It was observed at that time that it resembled species from the genus *Leodicites* but that the under side bearing the denticles was unlike that of any species of that genus. Also it was noted that forms of this sort did not fit very well in the genus *Oenonites*. For the present, species of this kind will be placed in the genus *Paleoenonites* in which there seems to be more characteristics than in *Oenonites* and *Leodicites*. Locality: Cheapside, Ontario.

Paleoenonites geometricus sp. nov.

Maxilla II. Plate 3, Fig. 24, 25

The jaw is large, angular, and nearly the shape of a parallelogram. The figured specimen measures 0.68 mm. in length and 0.45 mm. in width. A series of nine wide, blunt denticles are arranged in a curve and extends the full length of the jaw. The first and second denticles are about the same size, while the remaining ones are smaller and decrease in size only slightly to the narrow posterior extremity. The anterior margin is nearly straight and forms, at about a right angle with the outer margin, a wide angular shank. The inner lateral margin is also angular, and the area between the edge and the denticles is slightly concave or flattened. A large, deep fossa occupies most of the surface of the jaw. The margins of the fossa are slightly thickened and rounded.

Paleoenonites geometricus resembles in a general way *Paleoenonites latimarginatus*, plate 3, fig. 22, 23. *Oenonites* ? *dubius* Eller (1945) seems to be very similar in shape to *Paleoenonites geometricus*. They differ in the curvature and nature of the anterior area and margin and the shape of the fossa and its margins. Locality: Cheapside, Ontario.

Paleoenonites inops sp. nov.

Maxilla II. Plate 3, Fig. 28

Most specimens of this form are broken and without strength, especially along the outer margin. The jaw, however, is subtriangular in shape and the figured specimen measures 0.51 mm. in length. A series of six or seven sharp-pointed, triangular denticles extends nearly the full length of the jaw. The first and second denticles are large and are followed by smaller teeth

that decrease in size gradually to the posterior. The anterior margin is nearly straight and is in an oblique position to the lateral margins. Although the shank is broken it is broadly curved from a small bight adjacent to the anterior margin. A deep, narrow fossa extends nearly the full length of the jaw. The concave area on the surface between the slightly thickened margin of the fossa and the denticles is narrow.

Except for the angle of the anterior margin *Paleoenonites inops* is similar to a number of forms of this genus. Locality: Goderich, Ontario.

Paleoenonites sp.

Maxilla II. Plate 3, Fig. 29, 30, 34

Due to the incompleteness of the shank and outer margin a specific identification will not be attempted. The denticles and the margin of the fossa on the upper surface are similar to other forms of *Paleoenonites*. Locality: Goderich, Ontario.

Paleoenonites insperatus sp. nov.

Maxilla II. Plate 3, Fig. 31, 32

In outline the jaw is subtriangular and tapers to an acute posterior extremity. The figured specimen measures 0.61 mm. in length and 0.30 mm. in width. Along the inner margin a series of nine, conical, sharp-pointed, backward-directed denticles extends nearly to the posterior end. The first two denticles are large, thin, and seem to be adhered. From the fourth denticle, which is slightly larger than the third, the teeth decrease in size gradually to the posterior. The anterior margin is irregularly curved and forms an oblique angle with the inner and outer margins. It terminates in an unexpected acute extremity. A long, deep, narrow-to-wide fossa extends the full length of the jaw. The area on the under surface, between the thickened margins of the fossa, is wide and concave.

Paleoenonites insperatus is not very closely related to other forms of the genus. *Paleoenonites informis*, plate 3, fig. 9, 12, 26, 27, has an anterior margin that is somewhat oblique to the lateral margins and an acute extremity that is similar to *Paleoenonites insperatus*. Locality: Goderich, Ontario.

Paleoenonites lituus sp. nov.

Maxilla II. Plate 3, Fig. 33

The jaw is elongate and the figured specimen measures 0.65 mm. in length and 0.18 mm. in width. Along the inner margin a series of about 15 conical, sharp-pointed to blunt denticles extends nearly the full length of the jaw. The first denticle or fang is long, crooked, thin and pointed. The next seven teeth are small, pointed and perpendicular to the inner margin. The remaining denticles are large, blunt, fairly uniform in size, and point in a backward-direction. A large oval fossa occupies most of one side of the jaw. The margins of the fossa are thickened and rounded. Only a suggestion of a shank occurs on the outer margin.

In general shape *Paleoenonites lituus* is similar to other forms. The denticles are quite different from those of other species. Locality: Cheapside, Ontario.

Paleoenonites indentus sp. nov.

Maxilla II. Plate 3, Fig. 35, 36

The jaw is narrowly triangular and tapers from the anterior only slightly to the truncate posterior extremity. The figured specimen measures 0.49 mm. in length and 0.17 mm. in width. On the inner margin a series of nine conical, sharp-pointed, backward-directed denticles extends nearly to the posterior end of the jaw. The first denticle or fang is a little larger than the other teeth and it is slightly hooked. The remaining denticles increase in size slightly to the mid-area and then decrease in size posteriorly. The anterior margin is slightly incurved and then turns abruptly to form a small indented bight and an angular shank with the straight outer margin. A narrow, deep fossa occupies about three-fourths the length of the jaw. The margins of the fossa are thickened and rounded. One side of the jaw is convex while the narrow area between the fossa and the denticles on the opposite side is concave.

Except for the denticles and the shape of the shank, *Paleoenonites indentus* resembles, in a general way, *Paleoenonites castigatus* Eller (1945), *Paleoenonites lituus* plate 3, fig. 33, and *Paleoenonites formosus*, plate 3, fig. 38, 39. Locality: Goderich, Ontario.

Paleoenonites limulurus sp. nov.

Maxilla II. Plate 3, Fig. 37

The jaw is large, triangular in shape, wide anteriorly, and tapers to a pointed posterior extremity. The figured specimen measures 0.65 mm. in length and 0.30 mm. in width at the widest part. Along the inner margin a series of nine triangular, sharp-pointed denticles extends the full length of the jaw. The first three denticles are large and are followed by smaller teeth that decrease in size to the posterior. The denticles are mostly perpendicular to the margin of the jaw. The anterior margin is rounded and forms with the outer margin an angular shank. At the anterior end of the outer margin of the jaw is a small shank-like projection. A narrow, deep fossa extends most of the length of the jaw. The margins of the fossa are slightly thickened and rounded. One side of the jaw is irregularly concave and convex, while the opposite side is concave.

Paleoenonites limulurus resembles only in a general way other forms of the genus. Locality: St. Mary's, Ontario.

Paleoenonites formosus sp. nov.

Maxilla II. Plate 3, Fig. 38, 39

In shape the jaw is narrowly triangular, and when observed from one angle it tapers to an acute posterior extremity. The figured specimen measures 0.66 mm. in length and 0.28 mm. in width at the anterior third of the jaw. Along the inner margin a series of 11 triangular, sharp-pointed denticles extends nearly the full length of the jaw. The first denticle is fairly large, sharp-pointed and perpendicular to the lateral margins of the jaw. The posterior edge of the fang begins about opposite the third denticle. The second and third denticles are small, perpendicular to the jaw and slightly adhered. The remaining denticles are large and backward-directed. They

increase in size slightly to about the mid-area and then decrease very gradually in size to the posterior. From the fang the anterior margin curves gently and then incurves to form with the thin outer margin a nearly straight-sided shank. The fossa is narrow and shallow and extends about three-quarters of the length of the jaw. The area on the surface between the thickened and rounded margin is very narrow and concave. The opposite side of the jaw is generally convex except at the anterior end where it is flattened.

In shape *Paleoenonites formosus* is similar to a number of forms of this genus. They differ in the width of the jaw, the character and arrangement of the denticles, and the shape and size of the fossa and shank. Locality: Goderich, Ontario.

Paleoenonites flexuosus sp. nov.

Maxilla II. Plate 3, Fig. 40, 41, 42

The jaw is irregular in outline and shape. The figured specimen measures 0.55 mm. in length and 0.25 mm. in width. Along the curved inner margin a series of nine large, triangular, backward-directed denticles extends nearly the full length of the jaw. The denticles are oblique to the under surface of the jaw. The margins of the fossa are slightly thickened and rounded. The area between the margin of the fossa and the denticles may be flattened or slightly concave. The opposite surface of the jaw is irregularly convex.

Paleoenonites flexuosus is similar in outline to a number of forms of *Paleoenonites*. The irregular shape of the fossa is also observed in several species. The various forms differ in the number, shape, and arrangement of the denticles and in the shape of the shank. Locality: Delaware, Ohio.

Paleoenonites alpenaensis (Eller)

Maxilla II

Ocononites alpenaensis Eller, 1938. Annals of the Carnegie Museum, v. 27, p. 280, pl. 29, fig. 1, 2.

Paleoenonites alpenaensis (Eller), 1955. Annals of the Carnegie Museum, v. 33, p. 355, pl. 23, fig. 24.

This form was found to be plentiful at most localities of the Delaware Limestone that were studied.

Genus EUNICITES Ehlers, 1868

Eunicites lanceolatus sp. nov.

Maxilla IV or V. Plate 4, Fig. 1

The jaw is a single, angular, slightly arched, very sharp-pointed denticle. A large fossa occupies most of one surface and extends about three-quarters of the way along the posterior edge of the jaw. The margins of the fossa are thickened. In cross-section, the surfaces of the jaw are nearly at right angles and they are irregularly flattened or slightly concave. The figured specimen measures 0.77 mm. in length and about 0.22 mm. in width at the widest part.

Eunicites lanceolatus is similar in shape to other forms of the genus. In a

number of species the fossa is extended into the anterior end of the denticle. This is demonstrated in *Eunicites cavus* Eller (1945), *Eunicites apidodus* Eller (1955), and especially *Eunicites apiculatus* Eller (1955). Locality: Delaware, Ohio.

Eunicites admirandus Eller

Maxilla IV or V. Plate 4, Fig. 2

Eunicites admirandus Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 358, pl. 24, fig. 9.

The figured specimen measures 0.55 mm. in length. In most respects the Delaware Limestone specimens resemble the Potter Farm Formation (Devonian) forms very closely. In some specimens the difference is noticeable in the sharpness of the denticle or the angularity or roundness of the tooth. Locality: Goderich, Ontario.

Eunicites sp.

Maxilla IV or V. Plate 4, Fig. 3

Since considerable part of the jaw is missing, specific identification will not be attempted. It is similar to *Eunicites admirandus* Eller (1955) in a general way. One difference is that the curve of the denticle is in a different plane. Locality: Goderich, Ontario.

Eunicites florealis sp. nov.

Maxilla IV or V. Plate 4, Fig. 4

In outline the denticle or jaw is subtriangular, consisting of a wide, heavy base that tapers to a blunt, slightly hooked end. The figured specimen measures 0.58 mm. in length and 0.42 mm. in width. The anterior margin is slightly curved or nearly straight, while the posterior margin incurves abruptly to form a small hooked shank. A large fossa occupies nearly half of the surface of the jaw. The margins of the fossa are wide and rounded. One surface of the tooth is flattened or may be slightly concave.

Eunicites florealis is similar to *Eunicites altidorsalis* Eller (1955) except for the heaviness of the denticle and the shape of the fossa and shank. Locality: Goderich, Ontario.

Eunicites hemicyclus sp. nov.

Maxilla IV or V. Plate 4, Fig. 5

Semicircular in outline the jaw consists of a single denticle with a heavy, elongated shank or base. The denticle is conical, heavy, sharp-pointed and backward-directed. A long, deep fossa, wide anteriorly and narrow at the posterior, occupies more than half the area of the jaw. The margins of the fossa are thickened and rounded. The figured specimen measures 0.35 mm. in length.

This form is similar to *Arabellites uncinatus* Hinde (1882), *Eunicites colossus* Eller (1955), and *Eunicites clarus* Eller (1961). The forms differ

mostly in the size and shape of the fossa and the length and shape of the shank. Locality: St. Mary's, Ontario.

Eunicites ambocoelius Eller

Maxilla IV or V. Plate 4, Fig. 6

Eunicites ambocoelius Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 360, pl. 24, fig. 23.

In length the figured specimen is 0.45 mm. and in width 0.37 mm. The denticle is more pointed and the fossa deeper than the form described from the Potter Farm Formation of Michigan. Locality: Bloomfield, Ohio.

Eunicites apicalis ? Eller

Maxilla IV or V. Plate 4, Fig. 7, 8

Eunicites apicalis Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 356, pl. 24, fig. 1.

The figured specimen and other broken specimens suggest that the form may be *Eunicites apicalis* Eller (1955). Measurements suggest that the specimen may be around 1.0 mm. in width and in length nearly as much. *Eunicites denticuleatus* Eller (1942) and *Eunicites whiteae* Eller (1945) resemble *Eunicites apicalis* ? in proportions but differ in size, the shape of the fossa, and the curvature of the posterior margin. Locality: Goderich, Ontario.

Eunicites asaphus ? Eller

Maxilla IV or V. Plate 4, Fig. 9, 10

Eunicites asaphus Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 357, pl. 24, fig. 22.

Only imperfect specimens of this form were found. This was also true of the Potter Farm Formation specimens. The denticle of the Delaware Limestone form is much shorter and the jaw is wider in proportion than the originally described species. Locality: Goderich, Ontario.

Eunicites limbatus sp. nov.

Maxilla IV or V. Plate 4, Fig. 11, 12

The jaw consists of a short, single denticle with a wide, rounded, bordered base or shank. The posterior end is truncate. The figured specimen measures 0.42 mm. in width and 0.32 mm. in length. The fang is irregularly flattened and acute, but widens rapidly to the base. A small oval, shallow fossa is present on one side of the jaw. The margins of the fossa are wide, especially at the outer side. Adjacent and posterior to the fossa is a flat angular shank.

Eunicites limbatus is similar to *Eunicites ansatus* Eller (1945) except for the width of the shank and the shortness of the denticle. Locality: St. Mary's, Ontario.

Eunicites fimbriatus sp. nov.

Maxilla IV or V. Plate 4, Fig. 14, 15

The jaw consists of a single large, thick, angular denticle which tapers abruptly from a wide base to a very sharp, needle-like tooth. When observed from the side this small tooth seems to begin as a ridge on the surface of the jaw. The figured specimen measures 0.45 mm. in length and 0.57 mm. in

width. Along the very sharp edges of the denticle is a series of minute spines, hair-like crenulations or teeth. They begin adjacent to the needle-like tooth and extend the full length of the denticle. The minute fringe-like teeth on the anterior side of the denticle are much more closely arranged than those on the posterior side. A large oval fossa occupies about one-half of the upper side of the jaw. The margin or shank between the fossa and the denticles is wide and rounded. It appears to overlap the flattened or slightly concave inner area of the jaw. The under side of the jaw is convex except for the shank, which is flattened.

Denticles with minute spines or teeth have been found in a number of unrelated forms and from various geologic ages. Often very similar forms have been described but without these extra hair-like teeth. As an example, *Eunicites ambocoelius* is very like the above described species except for the wide margin or shank. There is no evidence, however, of minute teeth having been attached to the denticle. Other forms, *Eunicites geisacanthus* Eller (1945), *Eunicites acis* Eller (1945), *Eunicites barbaricus* Eller (1945), and *Nereidavus invisibilis* Eller (1940) unlike *Eunicites fimbriatus* have been described bearing minute teeth. In outline and shape very similar forms without extra teeth, and in the case of *Nereidavus invisibilis* with normal teeth, have been compared to these species. Perhaps at some particular time in the life of the animal these extra crenulations or saw-tooth projections developed on the sides of the denticles or jaw. Locality: Cheapside, Ontario.

Genus ANISOCERASITES Eller, 1955

Anisocerasites sp. indet.

Maxilla III. Plate 4, Fig. 13

The jaw is large and irregular in shape. In its broken condition it measures 0.51 mm. in length and 0.45 mm. in width. A series of five, possibly six conical, sharp-pointed denticles are present along the inner margin. The first denticle is medium in size and is set back from the other teeth. The second denticle is the largest and is followed by smaller teeth that decrease in size posteriorly.

Since this form is represented by only one specimen which is also broken, specific identification will not be attempted. The form cannot be compared closely with any other species but it has the characteristics of the genus. Locality: Goderich, Ontario.

Anisocerasites insignis sp. nov.

Maxilla III. Plate 4, Fig. 16

The jaw is large and remarkably heavy in appearance. The figured specimen measures 0.92 mm. in length and 0.85 mm. in width. Along the inner margin a series of five large, blunt, conical denticles extends the full length of the jaw. The denticles increase in size from the first tooth to the very large third denticle, and then decrease in size to the fifth, which is very small. The denticles are perpendicular to the slightly arched margin. A narrow, deep fossa extends the full length of the jaw. The fossa is notched at the anterior end. The margins of the fossa are very thick and rounded. The

anterior margin is gently curved and forms an irregularly shaped shank with the nearly straight outer margin. The posterior end of the jaw is rounded. One surface is highly convex while the opposite side is slightly concave or flattened.

Although *Anisocerasites insignis* falls within the qualifications of the genus, it does not correspond very closely to any other species. Locality: Goderich, Ontario.

Anisocerasites longidactylus sp. nov.

Maxilla III. Plate 4, Fig. 19

The jaw is elongate and the figured specimen, which is broken, measures 0.77 mm. in length. A series of seven sharp-pointed denticles occupies the inner margin. The first three denticles are minute and are directed slightly forward. The fourth or middle denticle is very long-fingered, angular, and slightly hooked. It is followed by three remaining teeth that are small and conical in shape. A fossa occupies part of one side of the jaw. Since the outer margin is broken the exact shape of the fossa cannot be described. Both surfaces of the jaw are irregular.

Anisocerasites longidactylus resembles, in a general way, *Anisocerasites acanthophorus* Eller (1955) and *Anisocerasites tridentus* (Stauffer) (1933). They differ in the number of denticles and the shape of the fossa. All three forms have the large middle denticle with the small teeth on either side. Locality: Delaware, Ohio.

Anisocerasites sp. indet.

Maxilla III. Plate 4, Fig. 17, 18

This form, although broken, seems worth figuring. The jaw is large and has a very large medium tooth with probably two to three smaller denticles on each side. The denticles are conical, sharp-pointed and perpendicular to the lateral margins. Locality: Delaware, Ohio.

Anisocerasites gigas sp. nov.

Maxilla III. Plate 4, Fig. 20, 21

The jaw is large, rounded and irregular in outline. The figured specimen measures 0.72 mm. in length and 0.95 mm. in width. A series of four blunt, conical denticles extends the full length of the jaw. The first tooth is minute and it is followed by a very large, heavy median denticle. The third and fourth denticles are small and decrease in size to the posterior. All the denticles are perpendicular to the lateral margin or may point slightly backwards. The anterior margin is deeply incurved and forms with the outer margin a large rounded shank. A large, deep fossa occupies most of the one side of the jaw including the shank. The margins of the fossa are wide, thickened, and rounded. The side of the jaw is convex except for the area adjacent to the denticles on the innerside.

Anisocerasites tanaodus (Eller) (1938) (1955) resembles *Anisocerasites gigas* very closely. They differ in the shape of the denticles and fossa. *Anisocerasites amplimarginatus* Eller (1955) is similar to *Anisocerasites gigas* only in a general way. Locality: Bloomfield, Ohio.

Anisocerasites globosus sp. nov.

Maxilla III. Plate 4, Fig. 22, 27, 28

In outline the jaw is nearly circular or globular. The figured specimens measure 0.42 mm. and 0.47 mm. in length. The width is probably slightly greater since the outer margin is thin and broken in all specimens. Along the curved inner margin a series of eight blunt, conical denticles extends the full length of the jaw. The first two denticles are minute and appear to overlap each other. The third tooth is very large and is followed by an even larger median denticle. The remaining denticles are smaller, closely compact and decrease in size to the posterior. A deep, angular fossa extends the full length of the jaw. The area between the thickened margin of the fossa and the denticles is concave. The opposite side of the jaw is convex.

Anisocerasites globosus does not compare very closely with other forms of the genus. Locality: St. Mary's, Ontario; Goderich, Ontario.

Anisocerasites feroculus sp. nov.

Maxilla III. Plate 4, Fig. 23, 24

The jaw is subtriangular in outline. The figured specimen measures 0.67 mm. in length and about 0.37 mm. in width. Along the inner margin a series of 11 conical, sharp-pointed, backward-directed denticles extends to the acute posterior extremity. The first two denticles are small and the third is large. The remaining teeth decrease in size gradually to the posterior. The denticles are oblique to the surface of the jaw. The anterior margin incurves and forms a shank with the straight outer margin. A deep, triangular muscle fossa extends the complete length of the jaw. The margins of the fossa are thickened and rounded. The areas adjacent to the denticles are slightly concave.

Anisocerasites feroculus is similar to *Anisocerasites validus* (Eller) (1955). They differ in the shape of the fossa and outer margins. Locality: Goderich, Ontario.

Anisocerasites sp. indet.

Maxilla III. Plate 4, Fig. 25, 26

A number of forms are present in the fauna similar to the figured specimen. In each case the jaws are broken and poorly preserved. Most of the specimens measure about 0.30 mm. in length and 0.40 mm. in width. There are two prominent denticles with smaller teeth on each side. The fossa is narrow and the margins are broken on all specimens. The surface of the jaw is irregular. Locality: Cheapside, Ontario.

Anisocerasites sp. indet.

Maxilla IV. Plate 4, Fig. 35, 36

Many specimens of this general form are present at most localities. In each case the specimens are broken or are not complete enough for specific descriptions. Most of the jaws have a small initial denticle followed by a more prominent tooth. The third and fourth denticles are small or minute. The posterior portion of the jaw is incomplete in all specimens examined. Locality: Goderich, Ontario.

Genus *UNGULITES* Stauffer, 1933*Ungulites indigestus* sp. nov.

Maxilla III. Plate 4, Fig. 29

The jaw is subtriangular with nearly straight margins. The figured specimen measures 0.65 mm. in length and 0.30 mm. in width. The first denticle is large, conical, and sharp-pointed and is a continuation of the lateral margins. Two small, conical, sharp-pointed, slightly hooked denticles are present on the inner margin. These are followed by two minute teeth. These denticles are arranged without too much order. An irregularly shaped fossa occupies about half the jaw. The margins of the fossa are wide, thickened and rounded. The surfaces of the jaw are irregularly convex and concave.

Ungulites indigestus cannot be compared very closely with other forms. Locality: Delaware, Ohio.

Ungulites fusus sp. nov.

Maxilla III. Plate 4, Fig. 30

A series of seven small, sharp-pointed, conical, forward-directed denticles is present on a subtriangular jaw. The figured specimen measures 0.38 mm. in length and 0.27 mm. in width. The first denticle or fang is thin, sharp-pointed and slightly hooked. The remaining denticles are small and nearly uniform in size and are oblique to the surface of the jaw. The posterior end of the jaw is widely spread and broadly notched. A large fossa occupies about half the area of the jaw. The surface is irregularly convex and concave.

Ungulites fusus does not seem to be very closely related to any other described form. Locality: Goderich, Ontario.

Ungulites sp. indet.

Maxilla III. Plate 4, Fig. 31

Due to the broken condition of the specimen and the fact that there is only one in the fauna, specific identifications will not be attempted. The jaw is large, subtriangular in shape with most of the posterior end missing. The broken specimen measures 0.67 mm. in length and 0.42 mm. in width. A large, elongated, slightly-hooked, probably sharp-pointed fang is present. Along the inner margin, which forms nearly a right angle, a series of seven small, tubular, sharp-pointed denticles of irregular length extends nearly to the end of the jaw. The first two denticles are directed nearly at right angles to the remaining five. The arrangement of the denticles in this manner has not been noted on other forms. The surfaces of the jaw are convex but irregular.

Except for the arrangement of the denticles *Ungulites* sp. indet. is similar to *Ungulites* ? *chilalloeus* Eller (1961). Locality: Goderich, Ontario.

Ungulites glyptus sp. nov.

Maxilla III. Plate 4, Fig. 32, 37

In outline the jaw is subtriangular. The figured specimens measure 0.63 mm. and 0.58 mm. in length and about 0.27 mm. and 0.25 mm. in width. Along the inner margin a series of four small conical, sharp-pointed denticles extends nearly to the posterior end of the jaw. The first denticle or fang is thin, sharp-pointed and slightly hooked. The remaining teeth are nearly

uniform in size. A narrow fossa is present on one side of the jaw. The margins of the fossa are thin and usually broken. The surfaces of the jaw are irregularly sculptured or convex and concave.

There is a similarity between *Ungulites glyptus* and *Ungulites ? chilalloeus* Eller (1961). Locality: Goderich, Ontario.

Ungulites sp. indet.

Maxilla III. Plate 4, Fig. 33

So much of the jaw is missing that specific identification will not be attempted. Close examination suggests that only three large denticles were present on the inner margin. The first denticle is very large, conical and sharp-pointed. Considerable space separates the second medium-sized tooth. The third denticle is minute and points slightly backward. Not enough of the remaining posterior end of the jaw is present to warrant description. Locality: Goderich, Ontario.

Ungulites lupatus sp. nov.

Maxilla III. Plate 4, Fig. 38

The jaw is small and angular. The figured specimen measures 0.38 mm. in length and 0.25 mm. in width. Along the inner margin a series of seven denticles extends the full length of the jaw. The first denticle is thin, very long and sharp-pointed. The second tooth is small, blunt and conical. It is followed by two slightly larger denticles. The remaining teeth are small, sharp-pointed, and fairly uniform in size. A narrow, deep fossa extends from the anterior to the posterior end of the jaw. The margins of the fossa are slightly thickened and rounded.

Except for the denticles and the shortness of the first tooth, *Ungulites lupatus* is similar to *Ungulites sumnerae* Eller (1945) and *Ungulites longidentatus* Eller (1945). Locality: Delaware, Ohio.

Ungulites sp. indet.

Maxilla III. Plate 4, Fig. 39

This form, although broken, seems worth mentioning since it cannot be compared very closely to other species. The jaw is large and measures in its broken condition 0.52 mm. in length and 0.31 mm. in width. On the inner margin are four angular to conical denticles. The first tooth is very large and wide at the base. The remaining denticles are small and narrow and may be sharp-pointed. The surfaces of the jaw are irregularly concave and convex. Locality: Goderich, Ontario.

Genus STAUROCEPHALITES Hinde, 1879

Staurocephalites alterostris Eller

Staurocephalites alterostris Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 353, pl. 23, 8-15.

In size the jaws measure from 0.65 mm. to 1.02 mm. in length and 0.17 mm. to 0.37 mm. in width. A series of 12 to 14 triangular, sharp-pointed denticles extends along the inner margin nearly to the rounded posterior end. Most

of the denticles point slightly in a backward-direction. The first denticle is large and appears to be an extension of the thickened margins. The second denticle is small or minute. It is followed by 10 to 12 teeth that decrease in size uniformly to the posterior. The anterior margin of the jaw is straight and long and forms an acute angle with the lateral margins. Both sides of the jaw are slightly convex except near the denticles. A large, fairly narrow fossa extends the full length of the jaw where complete. The margins of the fossa are slightly thickened and rounded.

Kielan-Jaworowska (1961) has erected two new genera, *Vistulella* and *Mochtyella* for forms that belong to the genus *Staurocephalites*. Hinde erected this genus in 1879. An examination at the British Museum (Natural History) of the genotype *Staurocephalites niagarensis* Hinde (1879) and a species *Staurocephalites serrula* Hinde (1880) shows close relationship to the maxilla I of Kielan-Jaworowska's species. The fact that additional parts of of the jaw apparatus have been found in articulation does not invalidate a genus that was erected more than 80 years ago. Paleontology has many records in which parts of fossil plants and animals have been described separately under various genera before a complete form has been found. If the International Rules of Zoological Nomenclature are to be followed the first described genus rates priority. *Staurocephalites* species are common in Paleozoic rocks. Stauffer (1933) described four typical *Staurocephalites* forms and two species, *Lumbriconereites perfectus* and *Lumbriconereites modestus*, that should be included under the genus *Staurocephalites*. Another form, *Arabellites* sp. a, Stauffer (1933) was described as a fragment. Actually this specimen is fairly complete and should be included under the genus *Staurocephalites*. *Staurocephalites articulatus* Eller (1955), and *Staurocephalites aequilateralis* Eller (1955) have characteristics similar to *Staurocephalites alterostris*. Eller (1961) described four forms of *Staurocephalites* that are related in a general way to *Staurocephalites alterostris*. Heretofore the writer has considered jaws of this type to be maxilla II. Kielan-Jaworowska (1961) has demonstrated from articulated specimens that they are maxilla I. Locality: Cheapside, Ontario; St. Mary's, Ontario.

Staurocephalites latibrachiatus sp. nov.

Maxilla I. Plate 5, Fig. 3, 4

At the anterior the jaw is wide, narrowing gradually to the blunt posterior end. The well armed figured specimen measures 0.87 mm. in length and 0.35 mm. at the widest part. A series of 11 large, triangular, sharp-pointed denticles extends in a curve the full length of the jaw. The first denticle, while not as long as some of the adjacent ones, is wider at the base and conical in shape. It is pointed forward while the rest of the denticles are directed toward the posterior. The first three or four teeth are large, especially for the size of the jaw. They then decrease rapidly in size to the posterior end. The anterior margin is irregular and terminates in a small angular shank. The lateral margins are curved. A large fossa, wide anteriorly and narrow posteriorly, occupies the full length of the jaw. The margins of the fossa are thickened and rounded.

Staurocephalites latibrachiatus is similar in a general way to a number of forms in the genus. Locality: Delaware, Ohio.

Staurocephalites liratus sp. nov.

Maxilla I. Plate 5, Fig. 5, 6

The size of the jaw is large and wide. The figured specimen measures 1.12 mm. in length and about 0.32 mm. in width. Along the curved inner margin a series of 14 triangular, sharp-pointed, backward-directed denticles extends nearly the full length of the jaw. The denticles are fairly uniform and decrease gradually in size to the rounded posterior end. An outer margin incurves at about the anterior third of the jaw. The area along the posterior two-thirds of this margin and adjacent to the denticles is slightly furrowed, and concave, and may have been the location of a secondary jaw. A large, deep fossa extends the full length of the jaw. It is wide anteriorly and narrow posteriorly. The margins of the fossa are slightly thickened and rounded.

There is a slight resemblance between *Staurocephalites liratus* and *Staurocephalites paquettensis* Eller (1945). They differ at the anterior end of the jaw and in the arrangement of the denticles. Locality: St. Mary's, Ontario.

Staurocephalites icosidactylus sp. nov.

Maxilla I. Plate 5, Fig. 7

The jaw is long and narrow and the figured specimen measures 0.63 mm. in length and about 0.2 mm. in width. Along the inner margin a series of 20 to 22 backward-directed denticles extends the full length of the jaw. The first denticle is triangular in shape and very sharp-pointed. It is followed by two teeth that are small. The fourth denticle is larger and sharp-pointed and it is followed by three large, wide, blunt denticles. From this point they decrease in size gradually to denticles that are so minute that they can hardly be detected. The anterior of the jaw tapers to an acute end, while the posterior extremity is blunt or rounded. A large, deep fossa extends the full length of the jaw. The margins of the fossa are thickened and rounded. The area between the margin of the fossa and the denticles is concave, while the opposite side is convex.

There are a number of forms of *Staurocephalites* that resemble *Staurocephalites icosidactylus*. *Staurocephalites dentatus* Stauffer (1933) has the same general shape and similar minute posterior denticles but differs in other ways. There is a general resemblance in shape and in the presence of minute posterior denticles between *Staurocephalites appositus* Eller (1945) and *Staurocephalites icosidactylus*. Locality: St. Mary's, Ontario.

Staurocephalites fraternus sp. nov.

Maxilla I. Plate 5, Fig. 8

The jaw is elongate and the figured specimen measures 0.71 mm. in length and about 0.21 mm. in width. Along the inner margin a series of 13 triangular, sharp-pointed, backward-directed denticles extends to the posterior end. The first denticle is slightly larger and appears, when viewed from the side, to be a continuation of the margins. The next seven denticles are nearly uniform in size and the remaining four or five are small and also nearly uniform in size. The anterior margin is straight and oblique to the lateral

margins while the posterior end is rounded. A narrow, deep fossa extends the full length of the jaw. One margin is thickened and rounded while the other is thin and broken. The area between the thickened margin and the denticles is slightly concave.

There is a general resemblance of *Staurocephalites fraternus* to other forms of the genus. Adhering to this jaw at the anterior end is a small cone-shaped denticle that can be allied to this form as a maxilla IV or V. Locality: Cheap-side, Ontario.

Staurocephalites fractus sp. nov.

Maxilla I. Plate 5, Fig. 9, 10

In outline the jaw is elongate and probably narrow. The margins of the specimens are mostly broken. The figured specimens measure 0.55 mm. and 0.61 mm. in length and about 0.16 mm. and 0.13 mm. in width. Along the inner margin a series of 11 to 13 conical, sharp-pointed, backward-directed denticles extends nearly to the blunt or rounded posterior extremity. The first denticle is large and forms a sharp angle with the acute anterior end. The second denticle is small and is followed by larger teeth that decrease in size very little to the posterior end of the jaw. A narrow, deep fossa extends the full length of the jaw. The margins of the fossa are usually frail or broken. Both surfaces of the jaw are slightly concave.

While similar in a general way to other forms of *Staurocephalites*, the position of the anterior margin with the first denticle is different from other species. Locality: Delaware, Ohio.

Staurocephalites longirostris sp. nov.

Maxilla I. Plate 5, Fig. 11, 12

In size the jaw is wide in proportion to the length. The figured specimens measure 0.80 mm. and 0.88 mm. in length and 0.25 mm. and 0.26 mm. in width. Along the inner margin a series of 13 or 14 conical, sharp-pointed, backward-directed denticles extends to a point some distance from the posterior end of the jaw. The first denticle is large and beak-like and appears to be part of the margin. The remaining denticles are slightly smaller and decrease gradually to the posterior. The anterior end of the jaw is extended to a high peak while the posterior end is rounded. A narrow, deep fossa extends the full length of the jaw. One margin of the fossa is thin and usually partly missing. The sides of the jaw are flattened or slightly concave. A secondary jaw or row of denticles is present that appears to be a margin of the fossa. It is probably a maxilla II or III in which the articulation cannot be readily detected. The secondary jaw consists of about 13 small, triangular, sharp-pointed, backward-directed denticles. They are fairly uniform in size and extend about three-fourths the length of the larger jaw.

There is a similarity between *Staurocephalites longirostris* and *Staurocephalites alterostris* Eller (1955) and *Staurocephalites aequilateralis* Eller (1955) in general shape and especially in the arrangement of the secondary jaw. The forms differ in details and the denticles are unlike in size, shape, and arrangement. Locality: Goderich, Ontario.

Staurocephalites longus sp. nov.

Maxilla I. Plate 5, Fig. 13, 15, 16

In shape the jaw is narrow and elongate. The figured specimens measure 0.68 mm. and 0.67 mm. in length and about 0.16 mm. and 0.17 mm. in width. A series of 16 or 17 triangular, sharp-pointed, mostly backward-directed denticles extends nearly the full length of the jaw. The first denticle is small but has a wide base. It is followed by two minute teeth. The next six or seven denticles are large. These are followed by several minute teeth that are spaced very close together. On one side the larger teeth continue as ridges and valleys halfway across the jaw. A deep, narrow fossa extends the full length of the jaw. The posterior end of the fossa is open. The margins of the fossa are thickened and rounded. The area between the margin of the fossa and the denticles is concave while the opposite side is convex. Both the anterior and posterior ends of the jaw are rounded.

Staurocephalites longus does not resemble very closely other forms. The minute posterior denticles are similar to those of several species. Locality: Goderich, Ontario.

Staurocephalites insolens sp. nov.

Maxilla I. Plate 5, Fig. 14

This species is represented by only one specimen. Even though the margins are broken it seems worth describing. The jaw is large and wide and the figured specimen measures 0.97 mm. in length and about 0.37 mm. in width. Along the inner margin a series of 13 triangular, sharp-pointed denticles extends nearly the full length of the jaw. The first denticle is not large. It is followed by four or five backward-directed teeth. The remaining denticles decrease to minute size at the posterior end. A deep, wide fossa extends the complete length of the jaw. The margins of the fossa are thin and broken. Both the anterior and posterior ends of the jaw are blunt or rounded. The sides of the jaw are irregularly convex and concave. A small secondary jaw, a maxilla III or IV, is present in the posterior area. The jaw has seven denticles of irregular size and shape. It is questionable whether this jaw is in articulation with the maxilla I.

There is a similarity between *Staurocephalites longus*, Plate 5, Fig. 13, 15, 16 and *Staurocephalites insolens*. They differ in the proportions of the length to the width. Locality: Delaware, Ohio.

Staurocephalites sp. indet.

Maxilla I. Plate 5, Fig. 17

Since only one broken specimen of this form was found specific identification will not be attempted. Locality: Bloomfield, Ohio.

Staurocephalites inclinatus sp. nov.

Maxilla I. Plate 5, Fig. 20

In shape the jaw is narrow, elongate and slightly bent. The figured specimen measures 0.62 mm. in length and 0.17 mm. in width. On the outer margin a series of 13 conical, sharp-pointed, backward-directed denticles ex-

tends nearly the full length of the jaw. The first two denticles are wider than the remaining teeth, which are narrow. Though the denticles are directed backward, they tend to be hooked slightly forward. The denticles are fairly uniform in size and become smaller only at the posterior end. A long, narrow fossa extends nearly the full length of the jaw. The anterior end of the jaw is rounded, while the posterior extremity is sharply pointed.

This form does not correspond very closely with other species. Locality: Cheapside, Ontario.

Staurocephalites sp. indet.

Maxilla I. Plate 5, Fig. 21

This form is represented by one broken specimen. The part of the margin adjacent to the denticles appears not to be broken. The space between the denticles and this margin would thus be very narrow and the fossa very wide. The first denticle, when observed from the under side, is large and seems to be a continuation of the anterior margin. Locality: Bloomfield, Ohio.

Genus DIOPATRAITES Eller, 1938

Diopatraites liratus sp. nov.

Mandible. Plate 5, Fig. 22

The right mandible is short, angular, and measures 0.51 mm. in length. Three angular, irregularly shaped teeth occupy the anterior margin of the large frontal plate. From the outer side the teeth decrease in size to the inner side. The teeth seem to continue as ridges and furrows halfway across the frontal plate. The shaft is short, wide anteriorly, and tapering to a blunt posterior end. The outer margin of the shaft is straight, with a broad angle at about the midpoint. The inner margin begins in a straight manner but incurves near the mid-area. The upper surface of the shaft is rounded, while the under surface is concave.

Diopatraites liratus does not correspond very closely with other forms. Locality: Goderich, Ontario.

Diopatraites ischypus sp. nov.

Mandible. Plate 5, Fig. 23

The mandible is narrow and elongate and has the appearance of a strong foot. The figured specimen is broken but would probably measure 0.80 mm. in length. A large, angular, smooth, slightly concave frontal plate is subrectangular in shape. Except for the anterior end the margins of the plate are incurved. Along the anterior margin is a series of eight conical, sharp-pointed teeth. The first tooth, beginning at the outer side, is minute. It is followed by a large tooth. The third tooth is again minute. The remaining teeth are large and decrease in size gradually to the inner side of the jaw. The shaft is long with straight margins. The upper surface of the shaft is angular and the under side is concave.

Diopatraites ischypus resembles other forms of the genus only in a general way. Locality: Cheapside, Ontario.

Genus ORTHOPELTA Eisenack, 1939

Orthopelta ? *humerus* sp. nov.

Carrier. Plate 5, Fig. 25, 26

The carriers are short and wide and the figured specimen measures 0.35 mm. in length. At the anterior end the carrier is wide and flattened and in the center is a small knob-like projection. This area is suitable for articulating with the posterior end of a maxilla I. The outside margins of the short shafts are curved while the inner margins are slightly incurved. At the widened posterior end are three knob-like projections. The surfaces are irregularly concave and convex.

Orthopelta ? *humerus* cannot be compared closely to any other form. *Orthopelta* ? *femoralis* Eller (1945) has a triformed end similar to *Orthopelta* ? *humerus*. Locality: Goderich, Ontario.

Genus MARPHYSAITES Eller, 1945

Marphysaites sp. indet.

Carrier? Plate 5, Fig. 27

Since the posterior end of the carrier is missing specific identification will not be attempted. At the posterior end where the carrier is broken the margins flair out slightly. The anterior margin and part of the outer margin are thickened. Adjacent to the margins the carrier is concave. Locality: Goderich, Ontario.

Marphysaites junctus sp. nov.

Carrier? Plate 5, Fig. 28

The carriers are narrow and elongate. The figured specimens measure 0.61 mm. in length and 0.15 mm. in width. From the blunt, articulating or connecting anterior end the carriers incurve slightly and decrease in width gradually to the acute posterior end. The upper surface of the carrier is convex while the under surface is slightly concave.

Marphysaites aptus Eller (1945) was described as a mandible, based on its resemblance to species of the modern genus *Marphysa* Savigny. It seems possible, however, that these structures may be carriers. The anterior margin could well be the articulating surface of a Maxilla I. Some species of the modern genus *Leodice* Savigny have carriers not too unlike *Marphysaites junctus*. Locality: Cheapside, Ontario.

Marphysaites gomphoides sp. nov.

Carrier? Plate 5, Fig. 29, 30

In size the carriers are very large. The figured specimen measures 0.88 mm. in length and 0.37 mm. at the anterior end. It is rather difficult to tell which is the upper and which the under side of the carrier. At the anterior end, if the carriers are oriented correctly, there is a wide, rounded, flattened or slightly concave area that extends beyond the incurved inner margin. This is perhaps the upper side of the right carrier and a similar structure of the left carrier would articulate on this area. The anterior end is rounded and

club-like, while the posterior end is blunt. The sides of the carrier are nearly straight and they do not decrease in width posteriorly.

Marphysaites gomphoides does not correspond very closely to any other form. Locality: Goderich, Ontario.

Genus SILUROPELTA Eller, 1939

Siluropelta jaculus sp. nov.

Mandible. Plate 5, Fig. 31

The mandible is narrow and elongate. The figured specimen measures 0.65 mm. in length and about 0.19 mm. in width at the anterior end. The inner and outer margins are nearly straight and terminate in an acute posterior extremity. At the anterior the margin curves to form a short, blunt, slightly-hooked shaft. The mandible is flat or convex on the upper surface and slightly concave on the under side.

Siluropelta jaculus, because of the narrow posterior, is unlike other forms of the genus. Locality: St. Mary's, Ontario.

Siluropelta laeviculus sp. nov.

Mandible. Plate 5, Fig. 32, 33

In shape the mandible is wide and not elongate. The figured specimen measures 0.60 mm. in length and 0.24 mm. in width at the widest place. The inner margin is straight except at the posterior end where it incurves slightly. The outer margin curves broadly and terminates with the inner margin in an acute posterior end. The anterior margin incurves slightly to form a short, slightly-hooked shaft or spine. The under side is flat or nearly smooth except near the inner margin where it becomes slightly concave. Except for a flattened area at the outer margin the upper side is convex.

Siluropelta laeviculus is unlike other forms due to the shortness of the shaft and the acute posterior. Locality: St. Mary's, Ontario.

Siluropelta accommodus ? (Eller)

Mandible. Plate 5, Fig. 34

Diopatraites accommodus Eller, 1955. Annals of the Carnegie Museum, v. 33, p. 371, Pl. 26, Fig. 21.

The figured specimen measures 0.98 mm. in length and about 0.27 mm. in width. There is a close resemblance between this form and *Diopatraites accommodus* Eller (1955). Both have the same appearance and outline. They differ mostly in width, angularity and robustness. Locality: Cheapside, Ontario.

Genus CHITINODENDRON ? Eisenack

Chitinodendron ? sp.

Plate 5, Fig. 24

At a number of localities in the Delaware limestone chitinous-like bladder-shaped objects were found in the residues. Eisenack (1937) figured a number of forms from the Silurian of the Baltic region that resemble these Devonian

specimens in a general way. Most of the Delaware specimens are very uniform in shape and size. All of the specimens have irregular surfaces and a crushed appearance due to the apparent thinness of the walls. An average specimen measures about 0.72 mm. in length, not counting the tube, and about 0.30 mm. in width. Attached to the end or ends of the form is a tube-like projection. It is wide at the base but narrows rapidly. Several specimens bore a thread-like tubular connection or projection about 0.30 mm. long. One was bifurcate. In most specimens the tube was broken off close to the body of the form. A few specimens had short tubular projections at both ends. A few flattened, thread-like tubular objects were noted in the residue but not proportionate to the bladder-shaped objects. Since the material was collected on sieves not finer than one hundred mesh it is possible that most of them were lost. These residues contained many strange and interesting objects, but since the main interest in the material was scolecodonts not much attention was given to other forms. The genus *Chitinodendron*, as far as has been determined, has not been reported before in North America. Locality: Goderich, Ontario.

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EXPLANATION OF PLATE 1

Figures magnified about 28 times.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- | | |
|-----------------------|---|
| Fig. 1 | <i>Arabellites goniocerus</i> sp. nov.
Maxilla I (28734) |
| Fig. 2, 3, 4 | <i>Arabellites comis</i> Eller
Maxilla I (28737, 28744) |
| Fig. 5, 6 | <i>Nereidavus forcicarinatus</i> sp. nov.
Maxilla I (28755) |
| Fig. 7, 8, 11, 12, 13 | <i>Nereidavus incrassatus</i> sp. nov.
Maxilla I (28758, 28759, 28760) |
| Fig. 9, 10 | <i>Nereidavus hastatus</i> sp. nov.
Maxilla I (28766) |
| Fig. 14, 15 | <i>Nereidavus incomptus</i> sp. nov.
Maxilla I (28767) |
| Fig. 16, 17 | <i>Drilonereisites gracillimus</i> sp. nov.
Maxilla I (28952) |
| Fig. 18 | <i>Ildraites incredibilis</i> sp. nov.
Maxilla I (28777) |
| Fig. 19, 20 | <i>Ildraites insignis</i> sp. nov.
Maxilla I (28778) |
| Fig. 21, 22 | <i>Ildraites invalidus</i> sp. nov.
Maxilla I (28779) |
| Fig. 23 | <i>Leodicites</i> sp. indet.
Maxilla II (28954) |
| Fig. 24, 25, 26 | <i>Ildraites unexpectatus</i> sp. nov.
Maxilla I (28782) |

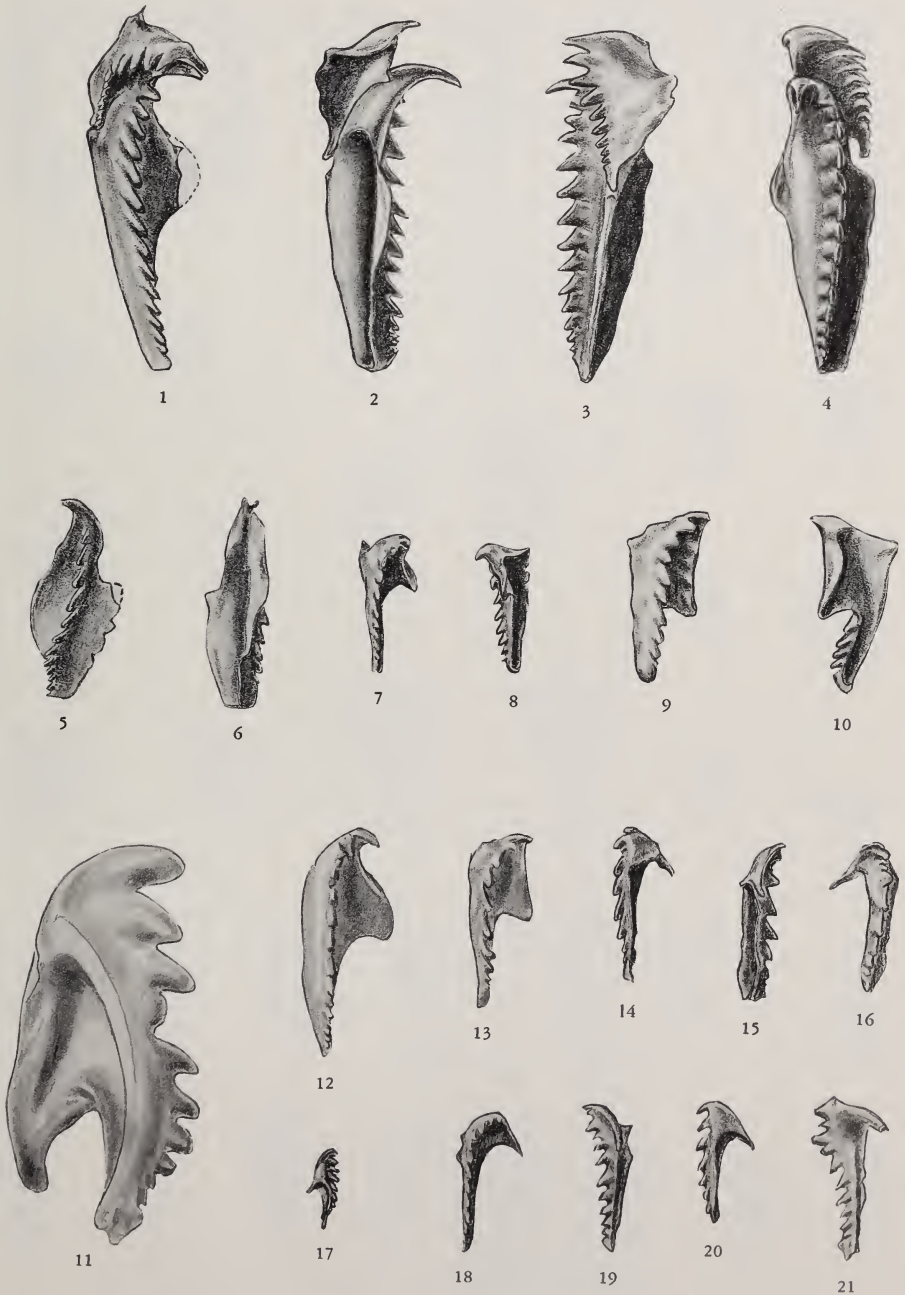


EXPLANATION OF PLATE 2

Figures magnified about 28 times.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- | | |
|---------------------|---|
| Fig. 1, 2, 3, 4, 12 | <i>Lumbriconereites jugosus</i> sp. nov.
Maxilla I (28801, 28802) |
| Fig. 5, 6 | <i>Lumbriconereites labiosus</i> sp. nov.
Maxilla I (28812, 28813) |
| Fig. 7, 8 | <i>Lumbriconereites flexuosus</i> sp. nov.
Maxilla I (28814) |
| Fig. 9, 10, 13 | <i>Lumbriconereites latifrons</i> sp. nov.
Maxilla I (28816) |
| Fig. 11 | <i>Leodicites fluctuosus</i> sp. nov.
Maxilla II (28821) |
| Fig. 14, 15, 16, 21 | <i>Leodicites inordinatus</i> sp. nov.
Maxilla II (28822, 28823) |
| Fig. 17 | <i>Leodicites inornatus</i> sp. nov.
Maxilla II (28824) |
| Fig. 18, 19 | <i>Leodicites finilimus</i> sp. nov.
Maxilla II (28825) |
| Fig. 20 | <i>Leodicites heteropsis</i> sp. nov.
Maxilla II (28829) |



EXPLANATION OF PLATE 3

Figures magnified about 28 times.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1, 2, 3, 4 *Drilonereisites longiscusculus* sp. nov.
Maxilla I (28950, 28951)
- Fig. 5, 6, 7 *Leodicites incertus* sp. nov.
Maxilla II (28830)
- Fig. 8 *Paleoenonites latidorsatus* sp. nov.
Maxilla II (28841)
- Fig. 9, 19, 26, 27 *Paleoenonites informis* sp. nov.
Maxilla II (28842, 28843, 28844, 28845)
- Fig. 10 *Paleoenonites incurvus* sp. nov.
Maxilla II (28846)
- Fig. 11 *Paleoenonites latissimus* sp. nov.
Maxilla II (28847)
- Fig. 12 *Paleoenonites hiulcus* sp. nov.
Maxilla II (28848)
- Fig. 13 *Leodicites inflatus* sp. nov.
Maxilla II (28832)
- Fig. 14, 15 *Paleoenonites lacinatus* sp. nov.
Maxilla II (28849)
- Fig. 16, 17 *Paleoenonites lacertosus* sp. nov.
Maxilla II (28855)
- Fig. 18 *Paleoenonites flaccidus* sp. nov.
Maxilla II (28856)
- Fig. 20 *Leodicites indecorus* sp. nov.
Maxilla II (28831)
- Fig. 21 *Paleoenonites hexadactylus* sp. nov.
Maxilla II (28857)
- Fig. 22, 23 *Paleoenonites latimarginatus* sp. nov.
Maxilla II (28858)
- Fig. 24, 25 *Paleoenonites geometricus* sp. nov.
Maxilla II (28859)
- Fig. 28 *Paleoenonites inops* sp. nov.
Maxilla II (28860)
- Fig. 29, 30, 34 *Paleoenonites* sp.
Maxilla II (28861, 28862)
- Fig. 31, 32 *Paleoenonites insperatus* sp. nov.
Maxilla II (28863)
- Fig. 33 *Paleoenonites lituus* sp. nov.
Maxilla II (28864)
- Fig. 35, 36 *Paleoenonites indentus* sp. nov.
Maxilla II (28866)
- Fig. 37 *Paleoenonites limulurus* sp. nov.
Maxilla II (28868)
- Fig. 38, 39 *Paleoenonites formosus* sp. nov.
Maxilla II (28869)
- Fig. 40, 41, 42 *Paleoenonites flexuosus* sp. nov.
Maxilla II (28871)



EXPLANATION OF PLATE 4

Figures magnified about 28 times.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1 *Eunicites lanceolatus* sp. nov.
Maxilla IV or V (28878)
- Fig. 2 *Eunicites admirandus* sp. nov.
Maxilla IV or V (28879)
- Fig. 3 *Eunicites* sp.
Maxilla IV or V (28880)
- Fig. 4 *Eunicites florealis* sp. nov.
Maxilla IV or V (28881)
- Fig. 5 *Eunicites hemicyclus* sp. nov.
Maxilla IV or V (28882)
- Fig. 6 *Eunicites ambocoelius* Eller
Maxilla IV or V (28883)
- Fig. 7, 8 *Eunicites apicalis* ? Eller
Maxilla IV or V (28884)
- Fig. 9, 10 *Eunicites asaphus* ? Eller
Maxilla IV or V (28885)
- Fig. 11, 12 *Eunicites limbatus* sp. nov.
Maxilla IV or V (28886)
- Fig. 13 *Anisocerasites* sp. indet.
Maxilla III (28889)
- Fig. 14, 15 *Eunicites fimbriatus* sp. nov.
Maxilla IV or V (28887)
- Fig. 16 *Anisocerasites insignis* sp. nov.
Maxilla III (28891)
- Fig. 17, 18 *Anisocerasites longidactylus* sp. nov.
Maxilla III (28892)
- Fig. 19 *Anisocerasites* sp. indet.
Maxilla III (28893)
- Fig. 20, 21 *Anisocerasites gigas* sp. nov.
Maxilla III (28894)
- Fig. 22, 27, 28 *Anisocerasites globosus* sp. nov.
Maxilla III (28896, 28897, 28898)
- Fig. 23, 24 *Anisocerasites feroculus* sp. nov.
Maxilla III (28902)
- Fig. 25, 26 *Anisocerasites* sp. indet.
Maxilla III (28903)
- Fig. 29 *Ungulites indigestus* sp. nov.
Maxilla III (28904)
- Fig. 30 *Ungulites fusus* sp. nov.
Maxilla III (28905)
- Fig. 31 *Ungulites* sp. indet.
Maxilla III (28906)
- Fig. 32, 37 *Ungulites glyptus* sp. nov.
Maxilla III (28907)
- Fig. 33 *Ungulites* sp. indet.
Maxilla III (28953)
- Fig. 34 *Leodicites lacunosus* sp. nov.
Maxilla III (28834)
- Fig. 35, 36 *Anisocerasites* sp. indet.
Maxilla IV (28910)
- Fig. 38 *Ungulites lupatus* sp. nov.
Maxilla III (28911)
- Fig. 39 *Ungulites* sp. indet.
Maxilla III (28912)



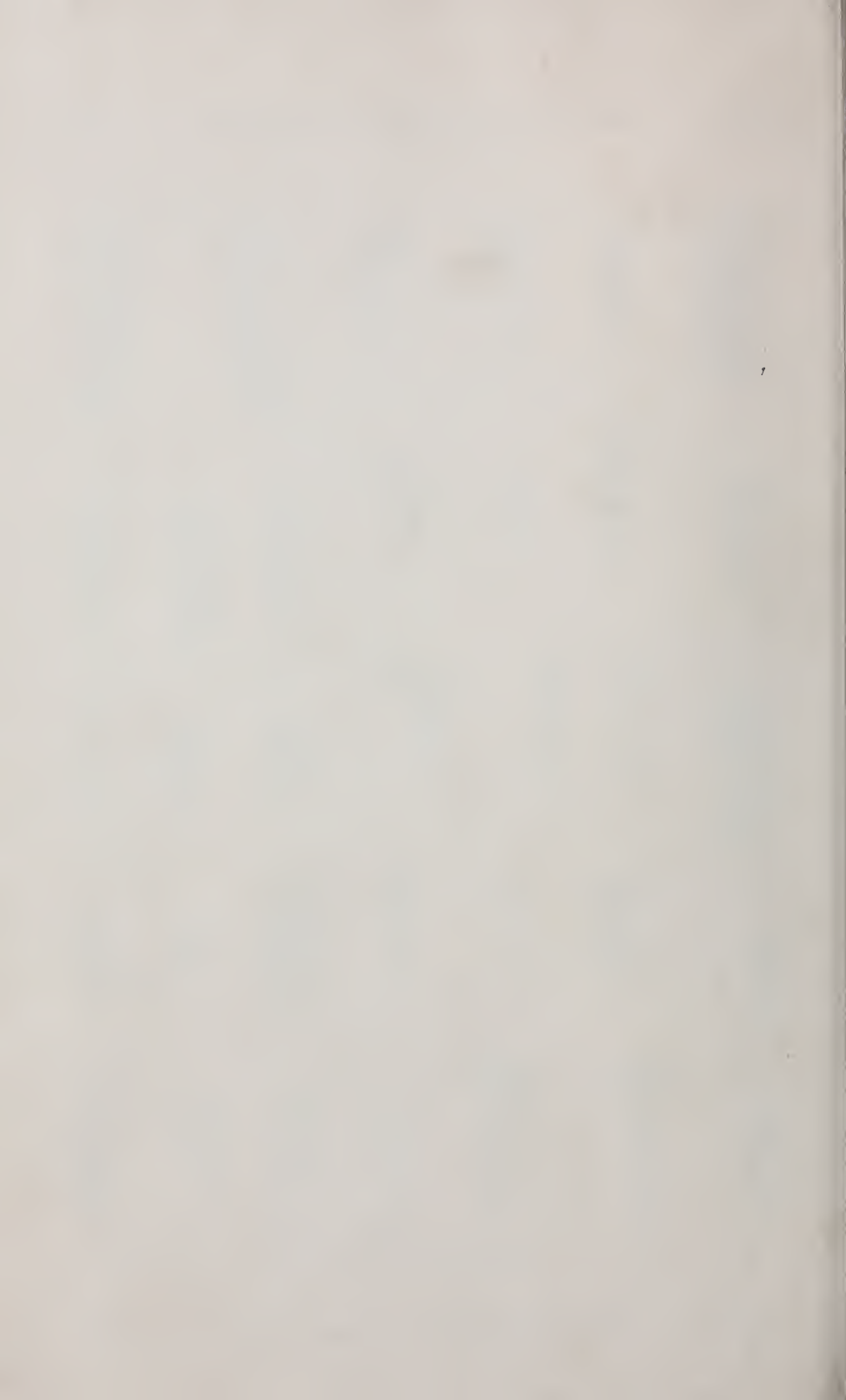
EXPLANATION OF PLATE 5

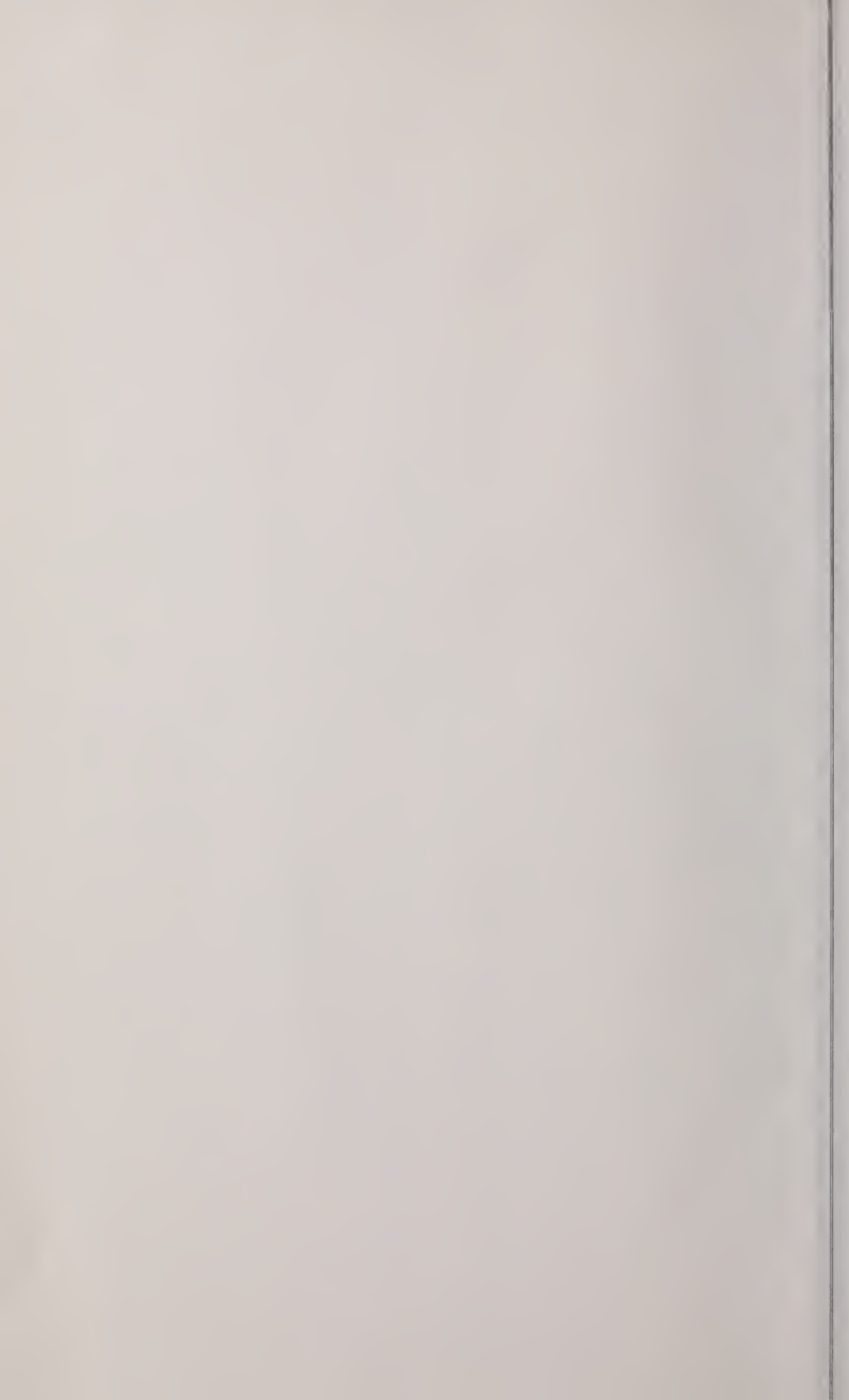
Figures magnified about 28 times.

Numbers in parentheses indicate Carnegie Museum catalogue numbers of the respective type specimens.

- Fig. 1, 2 *Staurocephalites alterostris* Eller
Maxilla I (28913, 28914)
- Fig. 3, 4 *Staurocephalites latibrachiatius* sp. nov.
Maxilla I (28921)
- Fig. 5, 6 *Staurocephalites liratus* sp. nov.
Maxilla I (28923)
- Fig. 7 *Staurocephalites icosidactylus* sp. nov.
Maxilla I (28925)
- Fig. 8 *Staurocephalites fraternus* sp. nov.
Maxilla I (28926)
- Fig. 9, 10 *Staurocephalites fractus* sp. nov.
Maxilla I (28927, 28928)
- Fig. 11, 12 *Staurocephalites longirostris* sp. nov.
Maxilla I (28929)
- Fig. 13, 15, 16 *Staurocephalites longus* sp. nov.
Maxilla I (28932)
- Fig. 14 *Staurocephalites insolens* sp. nov.
Maxilla I (28933)
- Fig. 17 *Staurocephalites* sp. indet.
Maxilla I (28934)
- Fig. 18, 19 *Leodicites lamellosus* sp. nov.
Maxilla II (28835)
- Fig. 20 *Staurocephalites inclinatus* sp. nov.
Maxilla I (28936)
- Fig. 21 *Staurocephalites* sp. indet.
Maxilla I (28937)
- Fig. 22 *Diopatraites liratus* sp. nov.
Mandible (28938)
- Fig. 23 *Diopatraites ischypus* sp. nov.
Mandible (28939)
- Fig. 24 *Chitinodendron* ? sp.
(28956)
- Fig. 25, 26 *Orthopelta* ? *humerus* sp. nov.
Carrier (28941)
- Fig. 27 *Marphysaites* sp. indet.
Carrier? (28942)
- Fig. 28 *Marphysaites junctus* sp. nov.
Carrier? (28943)
- Fig. 29, 30 *Marphysaites gomphoides* sp. nov.
Carrier? (28944)
- Fig. 31 *Siluropelta jaculus* sp. nov.
Mandible (28945)
- Fig. 32, 33 *Siluropelta laeviculus* sp. nov.
Mandible (28946)
- Fig. 34 *Siluropelta accommodus* ? (Eller)
Mandible (28949)

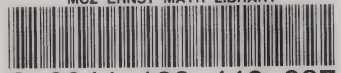






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